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CERTAIN HYDROLOGIC AND CLIMATIC CHARACTERISTICS OF THE SOUTHWEST REGION

PREPARED BY
J. H. DORROH JR.
Project Supervisor, Research

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To: State Conservationists — District Conservationists
Work Unit Conservationists — P-3 Specialists
Survey Supervisors — Zone Conservationists
Division Chiefs

From: Regional Conservator

Subject: Certain Hydrologic and Climatic Characteristics of the Southwest Region

Attached is copy of Regional Bulletin No. 98, Engineering Series #9, with the above title.

I think you will find the bulletin extremely interesting. I have personally read it and have encouraged its preparation. It is written in popular rather than technical style. We have known that in each section of the region there is a certain climatic pattern but have not known the reasons back of climatic peculiarities. This bulletin provides a number of the answers. The narrative portion provides a very interesting evening's reading and the appendix contains valuable information for both the farm planner and the engineer. It will constitute reference material in preparation of district programs and work plans as well as farm and ranch planning.

Cyril Luker, Regional Conservator

By [illegible], Acting

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CERTAIN HYDROLOGIC AND CLIMATIC CHARACTERISTICS OF THE SOUTHWEST REGION

Engineering technicians and others concerned with the problems involved in or related to rainfall have more often than not considered the erratic nature and distribution of precipitation in the Southwest as an inexplicable phenomenon. Variations in normal intensity patterns and total precipitation from one locality to another have been dismissed as whims of nature or many times given no consideration whatever. As time passes, however, more complete weather data, coupled with meteorological investigations, are indicating that ordinarily the nature, quantity, and distribution of precipitation peculiar to a given locality does not "just happen," but is the result of rather definite and orderly meteorological reactions. Given an elementary understanding of meteorology, the planning technician should be better acquainted with the reasons for the "weather" prevalent in his area and, consequently, trends in the frequency and intensity of storm rainfalls. For this reason, a brief discussion of certain meteorological principles and reactions is included.

The continuity and height of the Rocky Mountains are such that the meteorological characteristics of those parts of Region 6 lying to the east and west of this barrier can be said to differ widely, considering very broad and general climatological trends. For the sake of brevity reference will hereafter be made to the "eastern" and "western" zones of the Region, with the Rockies their line of demarkation. Figure 1 in the Appendix shows this general subdivision.

In order to clearly differentiate between component parts of this discussion, the several topics are given under separate headings, the first of which concerns the normal movement of air masses.

AIR MASS MOVEMENTS

Of utmost importance in the consideration of precipitation expectancy is the source and normal directional movement of air masses as they invade this Region. Thornthwaite 1/ and others state that there are five principal source regions of air contributing to the climate of the Southwest. These are as follows: 1. Cold, dry, Polar Continental (Canada and northward); 2. Cool, moist, Polar Pacific (northern Pacific Ocean); 3. Hot, dry, Tropical Continental (Mexico, extreme southwestern United States); 4. Warm, moist, Tropical Gulf (Gulf of Mexico and Caribbean); and 5. Warm, moist, Tropical Pacific (southern Pacific Ocean).

1/ Thornthwaite, C. Warren and Others. "Climate and Accelerated Erosion in the Arid and Semi-Arid Southwest, etc."

The weather at any given place may be influenced in many ways by these various air masses; however, the concensus appears to be that somewhat normal directional movements exist during the various seasons.

In the western zone the summer type of storm usually develops as moist, warm, Tropical Gulf air invades southern Arizona from Old Mexico, moving north and northeastward into northern Arizona, New Mexico, Colorado, and Utah. At times Tropical Pacific masses move from the southwest or west, following a more or less similar route. The effect of topographic barriers is such, however, that the weather of the eastern zone is not often influenced by Gulf air moving in such a circuitous path nor by the Tropical Pacific masses. As a result, summer storms of this area ordinarily occur as moist, warm air moves more directly from the Gulf of Mexico. The location of western New Mexico and southwestern Colorado with respect to these directional movements of air is such that the summer storm in these localities may be derived from either source. The characteristic movement of such air masses in summer is also shown in figure 1.

During the winter months precipitation primarily occurs as moist Polar Pacific air invades the western zone from the north, northwest, or west. The precipitation of eastern New Mexico and Colorado, however, is still primarily influenced by the invasion of moist air from the Gulf of Mexico. As in the case of summer storms, western New Mexico and southwestern Colorado also may receive invasions of air from the east or southeast. Figure 1 shows the general pattern of winter air mass movements.

The remaining air mass types, Polar Continental and Tropical Continental, are of significance only as they influence the weather through reaction with other air masses, or as they prevail during a particular period.

Tropical Continental air is developed over the Southwest from the heating of an air mass present in the area that has largely lost its original characteristics. The weather during such periods is characterized by high temperatures, low humidity, and an almost complete lack of precipitation. In Arizona and western New Mexico Tropical Continental air is particularly prevalent during late spring and early summer.

During the winter months Polar Continental air may invade the Southwest from the north or northeast. Such invasions are often characterized by intense cold and sustained periods of cold weather. If moist air masses are present in the area when these invasions occur, precipitation may result from the interaction of cold and warmer air. The extreme dryness of Polar Continental air, however, usually precludes the occurrence of precipitation unless other sources of moisture are available.

The foregoing discussion does not presuppose that the weather during a given year will conform to certain patterns. In drawing conclusions it must be kept in mind that the prevalence, directional movement, and characteristics of air masses follow no defined path during winter or summer. Polar Pacific air may invade the eastern zone at any time and, conversely, Tropical Gulf masses may be found in the western zone during the winter months. Reference

has been made to these phenomena only as they normally predominate during a particular season. Such predominance is most certainly the prevailing influence on the weather at any given location.

STORM TYPES

Interrelated with air mass movements in the Southwest are four common types of storms. The following discussion briefly delineates the causes and characteristics of each:

Condensation of moisture is obviously the basic principle involved in precipitation. The student of elementary physics is aware that condensation results from the cooling of moist air to a temperature below which water can no longer remain in a gaseous state. The predominating storm types which result in such cooling and consequent precipitation are four--convective, orographic uplift, lift convective, and convergence.

Convective:

During the summer months air is often heated at or near the ground surface to a degree such that it rises convectively through the overlying air. As the heated air ascends, the decreasing pressure allows expansion of this mass with consequent cooling and condensation. As droplets form, the latent heat of condensation retards the rate of cooling and further altitude is gained; thus additional cooling and condensation occurs. When drops of moisture reach sufficient size to overcome the rising air current, rainfall begins. The foregoing explanation of convective-type storms requires the presence of moist air and a continuous replacement of moist air as rainfall occurs. Blair 2/ states that, were the air completely saturated over a given place but no replacement occurred, it would not normally contain enough moisture to make more than one inch of rain. This type of storm, predominantly a summer phenomenon, is characterized by very high rainfall intensities of short duration occurring over rather limited areas. Although rainfall may occur at many locations on a given day, there is little conformity in either rates or amounts that may occur at two different places since very localized atmospheric conditions are the predominating factors involved. The presence of a supply of moist air over comparatively large areas explains the coincidence of comparatively isolated rainfall during certain periods.

Convective-type storms, therefore, do not ordinarily produce rain of a general nature nor is their influence of particular note when consideration of peak discharges from larger watersheds are concerned. They are of utmost importance, however, in the production of maximum runoff from watersheds of 10 square miles or less or from portions of large watersheds.

2/ Blair, Thomas A. "Weather Elements.

Although the convection storm is not uncommon during any season of the year, the absence of intense heating during winter minimizes the danger of floods resulting from this storm type during that period of the year.

Orographic Uplift:

As moist winds meet topographic barriers and are forced upward, the mechanical lift results in cooling, condensation, and precipitation. This storm type is not normally characterized by extremely intense precipitation and ordinarily has little influence on the production of flood flows from either small or large watersheds unless occurring in conjunction with other meteorological reactions or at points of rather abrupt changes in topography. The frequency and duration of these storms, however, are such that they are the predominating factor in the characteristic rise of annual precipitation with elevation.

Lift Convective:

The preceding discussions have considered the uplift and convective type of storms as more or less separate entities; i.e., the former as it occurs in the absence of intense heating and the latter as not necessarily being influenced by topography. Considerable evidence is accumulating, however, toward the conclusion that a third type of storm, herein termed lift-convective, (for want of a better name) often occurs in association with abrupt topographic barriers or changes. Unfortunately, little is known as to the mechanics of this storm type, yet observations and records continue to point toward its existence. It is probable that heat differentials found in conjunction with the mechanical lifting or turning or funneling of air results in much heavier precipitation than ordinarily will be found in either the uplift or convective-type storm alone. It is in fact not unlikely that at or near sudden changes in topography the characteristic rainfall intensities will far exceed those normally experienced elsewhere in the vicinity.

Convergence:

The meaning of the term "convergence" as herein used is neither that in popular meteorological use today nor does it strictly agree with its definition. For the sake of simplicity, however, and to serve a purpose in this discussion, it is used to cover the general storms not resulting from orographic uplift. It can also be interpreted as applying to immediate or subsequent reactions when air masses of dissimilar characteristics meet or override one another or when air converges toward a center and is forced upward.

Among these storm-types frontal activity, overrunning, and convergence of winds toward a central point are probably the most common.

The first, frontal activity, occurs when moving cold or warm air masses invade areas where the air is of a different temperature. The plane of contact and area of precipitation is known as a cold front in the first instance and a warm front in the latter. In both cases the cooling of moist air is the cause of precipitation.

The second common type of general storm results from the overrunning of cold air at high levels over areas where the air is warm and moist. This results in steep temperature gradients and promotes convective action over extensive areas.

The mechanics of precipitation in the third instance is evident from its description.

The convergence type of storm may occur during any season of the year. During the late spring, summer, and fall months, however, the presence of very moist air and greater heat differentials increases the likelihood of heavy precipitation periods and resulting flood flows. Characteristically these storms are not of exceptionally high intensity unless associated with localized convective action; yet intensities may be heavy and sustained resulting in high discharges from large watersheds. In fact, more often than not this storm type is the predominating cause of such floods.

QUANTITY AND DISTRIBUTION OF PRECIPITATION

In the preceding pages a brief explanation has been given as to the causes and characteristics of the various storm types and the normal movements of air masses from which such storms are derived. For practical application of this information certain logical assumptions can be made as to the probable influence of such features as topographic relief, changes in elevation, location with respect to storm movements, etc., on the quantity, distribution, and intensity of precipitation of a given locality.

Characteristic Annual Amounts:

Two predominating factors contribute toward the total annual precipitation at a given place: (1) Elevation, and (2) Location with respect to the source and normal directional movements of moist air masses.

The topographic complexity of Region 6 obviously prohibits a delineation of areas or zones where, due to prevailing elevations, the precipitation will total a given amount. Such quantities may change greatly over comparatively short distances and although generally the total annual precipitation rises with elevation, such is not always the case. Normally, however, a logical reason for the characteristic rainfall in a given locality can be found if the technician will attempt to reconcile existing conditions with the information outlined in the preceding part of the discussion.

Table 1 in the Appendix contains a list of selected stations and comments as to the probable reason for the characteristic annual precipitation at each station and at times the cause of differences in precipitation at stations of more or less equal elevation. Such reasoning may often be of assistance when it is desired to determine the average precipitation in locations where raingage records are not available.

Figure 2 also shown in the Appendix has been devised as a general guide to the technician when precipitation in general localities is being considered. The fact that the average annual precipitation may change greatly

within a few miles and that rainfall records are very scarce within the Region obviously prohibits the delineation of isohyetols to a degree of accuracy that would permit the selection of annual amounts peculiar to one particular city. The technician is advised therefore not to introduce an accuracy that does not exist. The figure should prove useful, however, if quick reference is needed to the average precipitation of any portion of the Region. For more concise data the technician is referred to publications of the U. S. Weather Bureau, all of which can be found at the Departmental Library in Albuquerque.

Characteristic Distribution:

The distribution of precipitation at a given place also is influenced by its location with respect to air mass sources, directional movements, and the presence or absence of topographic barriers between source regions and the locality under consideration. For example, the seasonal precipitation (April-September) at Clovis, New Mexico, amounts to 73% of the yearly precipitation; yet at Salt Lake City, Utah, this percentage is 44. The former location is closer to the source of the summer air masses (Gulf of Mexico) and few barriers of consequence are present to deplete the supply of moisture. Inasmuch as very little precipitation is received from Polar Pacific air during the summer months and the latter city is much farther removed from the source region of Tropical Gulf air, the percentage of yearly precipitation occurring from April to September is much lower. The characteristic movement and times of more frequent invasion result in the following general distribution patterns; Note: The ensuing discussion refers primarily to the seasonal precipitation as it is characteristic to the extensive areas below 8,000'. The amounts and times of occurrence of precipitation at higher elevations often bear little resemblance to those elsewhere. Reference to figure 1 will show that the extent of such areas is very limited.

Eastern Zone:

During the spring and summer months this area receives a very high percentage of the total annual precipitation. This is due to its proximity to the source of Gulf air which is active at these times. The fall and winter months, however, reflect the influence of barriers to the west and are very dry as compared to other portions of the year. Such a situation is of course conducive to the maximum utilization of annual precipitation for vegetative growth. Although the entire area receives favorable precipitation, the seasonal portions generally decrease from east to west. Figure 2 in the Appendix shows this general pattern.

Western Zone--New Mexico and Colorado:

Continuing westward from the Rocky Mountain barrier the trend continues toward decreasing proportions of the annual precipitation occurring in the spring and summer. The greater influence of Polar Pacific air and lesser influence of Gulf air tends to more evenly divide the year's precipitation. This reduction in directly useful moisture in spring and summer and the normally low annual precipitation results in a marked contrast between vegetative characteristics of this area and those of the Eastern Zone.

Western Zone--Arizona

The unusual position of this state with regard to sources and movements of moist air masses results in a rather complex distribution pattern. Whereas it might be thought from the trends mentioned heretofore that the amount of winter precipitation continues to rise (as compared with that during the spring and summer months) the movement of Gulf air masses from the south during summer alters the picture considerably.

The greater part of Arizona has two rather distinct rainy season, one during Dec.-Feb., and the other during July-Sept. Smith 3/ states that these two periods account for 78% of the year's precipitation. This is due to the activity of Polar Pacific air in the first instance and Gulf air in the latter. The contrast between this area and the others within the Region can be explained as follows:

During the transitory months of March-June Polar Pacific air is greatly lessened in activity while invasions of Gulf air have not begun. During August-Nov. the invasions of Gulf air are diminishing in intensity and are less frequent and the activity of Polar Pacific air is not great. In this connection it is interesting to note that although Gulf air is active during April-June in the Eastern Zone, the masses do not begin their trek into Mexico and northward until very late June or early July.

The southcentral part of Arizona, a point of invasion of Gulf air, although normally dry during April-June, receives such amounts of rainfall during the summer months that seasonal percentages are higher than at any other points of similar latitude. The proportion of rain occurring during the summer months alone equals and at times exceeds those recorded in the Eastern Zone. Such a situation is of course conducive to excellent stands of grasses but not to the dry land production of crops.

Moving northward from Mexico the trend is toward decreasing summer amounts with the influence of Polar Pacific invasions shown in the central part of the state. Apparently the combination of topographic features and the eastward movement of Polar Pacific air up the Salt River Valley results in an unusual amount of lifting with corresponding winter precipitation periods. The lines of equal percentages of seasonal rainfall (figure 2) will indicate a marked distortion in this area and in an entirely different direction from those in southern Arizona.

Although certain trends in summer rainfall may be noted in northern Arizona the complex topography and location of the area with respect to air mass movement results in a more or less equal distribution between the spring-summer, and fall-winter months.

3/ Smith, H. V. "Climate of Arizona."

Western Zone--Utah

Large areas of extreme northwestern New Mexico, northeastern Arizona, and eastern Utah are surrounded in all directions by lands of much higher elevation. This results in characteristically low precipitation and at times freakish distribution. As in the case of northern Arizona, seasonal precipitation is approximately equal to that during the remainder of the year. The normally low annual totals, however, when cut in half, leave very small quantities for vegetative growth.

The precipitation of central and western Utah again swings toward greater quantities of winter and less seasonal precipitation. As the source of Polar Pacific air is nearer, however, the extremely dry spring characteristic to Arizona is not in evidence. In fact considerable quantities of precipitation occur in April and May, although June ordinarily is the driest month. This additional moisture, however, although of benefit in starting vegetative growth, is somewhat obviated by low rainfall during the months of June-Sept. inclusive. It is interesting to note that whereas southern Arizona receives very little precipitation during April, May, and June, and often range grasses make no growth prior to July, the characteristic heavy rainfall during summer is sufficient to mature vegetation. On the other hand, in Utah there is sufficient winter and spring moisture for winter wheat and wheat grasses and certain other bunch grasses but the dry summer months are not conducive to the maintenance of grasses such as the grama. These statements presuppose a lack of irrigation water supply and do not pertain to high mountain areas where the precipitation is usually sufficient the year round to produce good vegetation.

Note: The precautions outlined heretofore concerning the literal use of precipitation data contained in figure 2 are also applicable to the information concerning rainfall patterns. Many discrepancies in localities over the Region can be found and the lines of equal seasonal precipitation percentages follow no hard or fast courses. Were additional precipitation data available, it is likely that both "isos" shown on figure 2 would be drawn somewhat differently. The technician is again referred to Weather Bureau for concise data as to the distribution pattern at a given locality.

INTENSITY CHARACTERISTICS OF REGION 6

Relation of Intensities to Major Changes in Elevation:

Brancato 4/ has suggested that, contrary to common belief, greater <u>amounts</u> of precipitation from individual thunderstorms are likely to come from those occurring over low-lying areas than from storms at higher elevation in the same locality. As moist air moves over relatively low, flat areas

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4/ Brancato, George N. "The Meteorological Behavior and Characteristics of Thunderstorms."

toward mountainous country, precipitation may occur, and it is evident that the total moisture content is decreasingly less as the air continues forward. The absence of uplift in the flat areas is not conducive to frequent rainfall periods, however, and lifting as it occurs over the mountain has the opposite effect. Such a situation, therefore, results in a normally high intensity and low frequency of precipitation over the low-lands with decreasing intensity and increasing frequency as moist air is forced upward into the higher elevations. Intensities in mountainous areas probably are influenced also by a change in the heat differentials. Available data concerning precipitation and runoff in the Southwest thus far have materially substantiated this hypothesis, although it must be realized that exceptions can be found. Thus in high, mountainous country, the normal precipitation during summer occurs in the form of very frequent rainfall periods of possibly heavy but not excessive intensities while in the low-lying areas the characteristic rainfall is of much higher intensity but occurs less frequently.

Characteristic Intensity Frequencies:

U. S. D. A. Miscellaneous Publication No. 204 5/ contains a summary of rainfall intensity frequencies for five, ten, fifteen, and thirty minutes and one, two, four, eight, sixteen, and twenty-four hour periods in terms on the order of once in two, five, ten, twenty-five, fifty, and one hundred years; i.e., that in a given time a certain amount of rain can be expected to occur once in a given period of years. Thus far, available data have been found reasonably accurate insofar as the eastern zone is concerned. It is, therefore, not likely that the technician will be seriously in error if intensities outlined in this publication are used, <u>but only as they pertain to that portion of the Region</u>.

Heretofore the effect of normal air mass movements on the quantity and distribution of precipitation within the Region has been discussed. A further analysis of existing records indicates that, to some extent at least, rainfall intensities likewise are influenced. Before proceeding further, however, this point must be emphasized: Rainfall of high intensity or long duration can occur at <u>any point</u> within the Region at <u>any time</u>. The likelihood or frequency of such occurrences, however, apparently "ties in" rather definitely with other conclusions concerning the influence of air mass movements.

Six facts are of primary importance as they influence intensity duration characteristics. They are: 1. As air masses move overland from source regions the amount of moisture per unit volume normally decreases; 2. During the late spring, summer, and early fall months the rainfall of Region 6 is derived principally from Gulf air; 3. Flood-producing precipitation normally occurs during this period; 4. Characteristic intensities outlined herein do not apply to high mountain areas; 5. Intensities at or near certain abrupt topographic barriers may be characteristically much higher

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5/ Yarnell, David L. "Rainfall Intensity Frequency Data."

than those indicated for the area as a whole; and 6. Intensity-duration of rainfall, not intensity alone, is the important factor in runoff determination.

The complexity of precipitation expectancy throughout the Region is such that no general statement will apply to even one major portion. For the purpose of this discussion the two zones are again subdivided into states or portions of states. It must be kept in mind, however, that the subdivisions are arbitrary and that no clear line of demarkation can be drawn.

Eastern Zone--New Mexico

The proximity of this area to the source of moist Gulf air is such that the characteristic storms may result in rainfall periods of very high intensities for short periods or heavy sustained intensities over a greater length of time. As progress is made westward from the Texas boundary, however, there is apparently a tendency toward decreasing intensity duration. Table II in the Appendix outlines the probable amounts of rainfall that might be expected to occur in periods of fifteen, thirty, sixty, and 120 minutes each ten, twenty-five, and fifty years at 20 stations within and near Region 6. From the nearest applicable station or stations the probable intensity-frequency of a given location can be found.

Eastern Zone--Colorado

The changes in normal intensity characteristics in the area follow somewhat the same directional movements as that of New Mexico. Intensity data for Pueblo and Denver, Colorado, Dodge City, Kansas, Cheyenne and Lander, Wyoming, and North Platte, Nebraska, will be found in Table II.

Western Zone -- New Mexico

As mentioned heretofore this area is influenced by the movement of Gulf air north-northwestward from the Gulf of Mexico, or other masses of the same origin moving north-northeastward from Old Mexico. Unfortunately, records in the area are very meager or totally lacking. As progress is made westward from the Rio Grande Valley and northward from the boundary of Old Mexico, there is a certain amount of evidence that normal intensities are somewhat less. This decrease follows more or less the same path as that taken by Gulf air masses. Data from El Paso, Texas, and State College, Albuquerque, and Santa Fe, New Mexico, are given in Table II. It is impossible to suggest what reduction in normal intensities may occur to the north and west of these stations; yet there is no reason to believe that a rise in intensity expectancies will be found.

Western Zone--Arizona

Presupposing the entrance of moist Gulf air from Old Mexico into southern Arizona and a normal movement north and northwest, it is not illogical to

again assume that a decrease in normal intensities occurs as the air mass progresses. Although a certain general trend is evidenced, the peculiar physiographic characteristics of the state tend to somewhat modify this premise. The intensity record at Tucson (Table II) indicates that considerable amounts of precipitation will be recorded with some regularity. The record at Phoenix, some 125 miles northwest, reflects a definite drop in intensity frequencies. The latter city, however, is at a much lower elevation, 1306 feet less, and on the downwind side of the Gulf air movement which increases the probability of overriding.

The relief map (Fig. 1) of Arizona shows numerous rather abrupt topographic rises over the southern section of the state and an almost continuous barrier extending from the New Mexico border in a more or less northwesterly direction across the major part of the state. This barrier is composed in a large part of the Mogollon rim, a high plateau rising rather abruptly from the lowlands. Since the Gulf air moves northward against the numerous mountains and rises in the path, it is possible that at virtually any location between the border of Old Mexico and high elevation of central to northcentral Arizona characteristic intensities equal to or greater than those at Tucson will occur.

On entering Arizona the moist Gulf air apparently is moving in more or less northwesterly direction possibly due to the influence of the high central mountain ranges of Old Mexico. The prevailing westerly winds ordinarily tend to deflect this air mass eastward; however, the continuity and height of the Mogollon rim may be responsible in part for the continuation westward of more than an ordinary part of the moisture. Leopold 6/ shows some of the highest 24-hour rains for the entire state occuring in the mountainous area north and west of Phoenix.

Fig. 1 shows that northeastern Arizona is to the leeward of Gulf air movements and generally lower in elevation than the Mogollon Plateau. As a result it is likely that much less moisture is available for the development of storms of high intensity-duration or frequent rainfall periods. The characteristic intensity-duration of rainfall in this area probably is somewhat on the order of or less than at Phoenix.

The location with respect to air mass movements, low elevation, and the attendant low annual rainfall of extreme western and southwestern Arizona minimizes the probability of high intensity rainfall occurring with frequencies comparable to those at Tucson or Phoenix, although rainfall of both high intensity and considerable duration have been recorded. The characteristic intensities of northwestern Arizona will be discussed in conjunction with Utah.

6/ Leopold, Luna B. "Characteristics of Heavy Rainfall in New Mexico and Arizona."

Another characteristic of rainfall in parts of Arizona is the prevalence and nature of winter storms. The latitude and comparatively low elevations of the southcentral portion of the state are such that the winter precipitation occurs largely in the form of rainfall. Few barriers of consequence are present between the mountainous parts of this section and the Pacific, a situation favorable toward the occurrence of winter storms both heavy and sustained. Polar Pacific air in winter and Tropical Pacific air in late spring and early fall may invade from the west or southwest carrying large quantities of moisture. As these masses meet the barriers mentioned heretofore the orographic uplift and accompanying convection may result in storms from which flooding is of major consequence. In no other part of the Region are heavy winter rain storms this prevalent.

Western Zone--Colorado

The exceptionally high elevations of a considerable part of this section is in itself an indication of low intensity rainfall. This, coupled with the fact that the area is far removed from sources of summer moisture, almost precludes the frequent occurrence of heavy or intense storms. Intensity frequencies taken from the 43-year record at Grand Junction and shown in Table II are surprisingly low and are difficult to ignore considering the length of time the station has been in operation. For the lower-lying areas the technician may, to be conservative, revise these upward 25% or more; however, nothing has been found that seriously questions the applicability of the Grand Junction record.

Western Zone--Utah

The northwestward movement of Gulf air from central Arizona apparently shifts to a somewhat north-northeast direction as it passes west of the higher elevation of northern Arizona. The Weather Bureau station at Modena, Utah, (45 miles west of Cedar City) lies in the path of this movement and data taken from the 39-year station record (table II) indicate that in northwestern Arizona and southwestern Utah prevailing intensities up to 120-minute periods remain relatively high. The Salt Lake City record, however, shows nothing in the 44 years of record that would indicate rainfall intensities of sufficient duration to result in unusual flooding except from very small watersheds. It is not illogical, therefore, to assume that as progress is made northward from Modena toward Salt Lake City the characteristic intensity-duration of rainfall becomes progressively less. It must be kept in mind, however, that a number of abrupt barriers are present in the area at which rainfall intensities may normally be higher than elsewhere in the vicinity. Intensities prevalent to northern Utah probably are similar to those at Salt Lake City.

Virtually no intensity data are available in southcentral and southeastern Utah. There is nevertheless some evidence that infrequent but heavy rainstorms occur along and near the abrupt escarpment areas. It is likely that intensity-duration characteristics of the area as a whole, however, fall between those of Modena, Utah, and Grand Junction, Colorado.

Runoff data collected in the remainder of the state, including the Uintah Basin, indicate that prevailing intensity-durations are low, probably approaching these at Salt Lake City.

OTHER CLIMATOLOGICAL CHARACTERISTICS

Characteristic Temperatures--

It is not often realized that the climate of Region 6 is of a complexity seldom found elsewhere. This lack of uniformity is rather strikingly shown by extremes in prevailing temperatures at various locations within the four states. Take, for example, the highest recorded temperature, 127° Fahr., at Parker, Arizona, as compared with the lowest temperature, -54° Fahr., which has been recorded at Steamboat Springs, Colorado. These extremes are of interest yet not too significant. A comparison of the average temperature, however, considering the year as a whole, brings out a contrast worthy of note. Considering the annual mean at Mohawk, Arizona, (74.5° Fahr.) and that at Corona, Colorado, (27.8° Fahr.) the technician may better realize what range in temperatures must be contended with in planning activities throughout the Region. In order to assist with the determination of temperature patterns as they may prevail in a given locality, a number of stations were selected and their mean monthly and annual temperatures are given in table III. Much additional information can also be taken from publications listed in "Principal Sources of Hydrologic and Climatic Data in Region 6" which is given in the Appendix.

Frost Free Periods--

Of utmost importance in intelligent planning is that period of the year during which vegetation will normally grow, presupposing the presence of adequate moisture. This portion of the year is commonly termed the frost free period, and data concerning its extent at many localities can be found in the Climatic Summaries of the Weather Bureau and table IV of this bulletin. Due to certain other factors not commonly considered, however, a word of caution should be given lest such information be used without qualification.

It is a well known fact that cold heavy air tends to drain from hillsides into valleys during the night forcing upward the warmer air present there. Such drainage often results in an "inversion" or a situation where air at and near the ground surface is colder than that above. As a result of this phenomenon valley areas often sustain frosts of greater severity and frequency than do the adjacent hillsides. This difference is more often than not sufficient to warrant the determination of whether Weather Bureau Stations from which data are taken are located in valleys or adjacent higher elevations before the information is used.

Another worthwhile consideration lies in the average monthly temperatures characteristic to a given locality. Whereas the length of a growing season is of importance it is also important to determine the relative amount of heat recorded during this season. In other words, if one locality has

a consistently higher average temperature than another this difference when translated into available heat day by day over a period of months result in faster and heavier growth with the resultant maturity of crops in the warmer area that would fail in the colder.

Characteristic Evaporation--

The extreme range in temperatures characteristic to various portions of the Region, together with changes in other climatological features, results in equally divergent evaporation rates. Meyer[7] gives a variation of from 100 inches or more in Arizona to less than 40 inches in certain parts of Colorado.

In order to assist the technician with the determination of approximate evaporation rates, table V has been devised. Average monthly and annual evaporation rates are included wherever available with the exception of records from certain stations not considered applicable to areas other than those immediately adjacent. The data given are in terms of land pan evaporation rates and as such are higher than the quantities that will be lost from free water surfaces. Various studies have indicated that to more nearly approximate the true evaporation rates a factor in the neighborhood of .70 should be applied.

As in the case of many other types of data certain precautions should be taken before such information is considered applicable to areas in which evaporation pans have not been in operation. It is well known that evaporation rates vary greatly with changes in wind velocity, humidity, temperature, elevation, etc., and that such changes often occur within comparatively short distances. Probably the best approach to the correct answer lies in an interpolation between existing station records of evaporation, using at the same time any other available data such as is mentioned above. Reference is again made to Mr. Meyer's publication if more concise information is desired.

SUMMARY OF CLIMATIC FACTORS

In summarizing this discussion several pertinent facts concerning the climate and precipitation characteristics of Region 6 are outlined below:

1. The principal sources of precipitation are from air masses originating in the Gulf of Mexico (summer) and the northern Pacific Ocean* (winter).

7/ Meyer, Adolph E. "Evaporation from Lakes and Reservoirs".

* With the exception of eastern New Mexico and eastern Colorado, where Tropical Gulf air remains the predominating type during both summer and winter.

2. Normally a greater percentage of the annual precipitation results from Gulf of Mexico** air masses.

3. The spring and fall months are transitory periods during which many and varied reactions may take place.

4. Intensities of precipitation are normally lower in hgih mountain areas than over the plains.

5. Annual quantities of precipitation normally rise with elevation but may vary widely from this rule under given conditions.

6. The preponderance of precipitation generally shifts from summer toward winter moving westward from eastern New Mexico and eastern Colorado and northward from southern Arizona.

7. There is a general trend toward decreasing intensity durations as the distance from moist air mass sources increases.

8. Prevailing temperatures over the Region cover an extremely wide range.

9. Frost free periods are indicative of the average growing season but unless used with caution may prove of little value in the establishment of which crops are most suitable to a given locality.

10. Land pan evaporation ranges from 100 to less than 40 inches. A factor of .70 should be applied to existing data if the evaporation from free water surfaces is desired.

RUNOFF ESTIMATES

Rates of Runoff from Rainfall--

An intelligent and thorough examination of a given watershed is a requisite to the proper estimate of probable runoff rates. All too often a cursory and hurried inspection of an area is made during which only one or two of the many pertinent characteristics are determined, while others and possibly the predominating factors are overlooked entirely. When it is considered that the most thorough watershed examinations are likely to lead to conclusions somewhat in error the importance of at least exhausting every source of information concerning the area becomes further emphasized.

A number of factors which may have their place in such a study are listed and discussed below. This guide should be followed or enlarged upon by technicians regardless of the formula, table or chart used in the final estimate.

** With the exception of western Arizona and western Utah, where winter precipitation predominates.

The influence of slopes pertinent to a given watershed is primarily reflected in velocity changes. Obviously during a given time and with a constant rate of rainfall more water will reach a point of outlet from a steeply sloping area than from one containing flat or rolling slopes, although the total quantity of runoff is equal. In the first instance, velocities are higher and a greater amount of runoff converges at the outlet during the time under consideration.

Contributing Area and Shape of Watersheds:

Failure to give due consideration to the effect of the shape of an area on maximum discharges is a common error. The shape of a watershed as the prevailing slope, can materially influence runoff by virtue of its effect in increasing or decreasing the contributing area and consequently the amount of discharge during a given time. For example, a bowl-shaped area contributing uniformly toward the center will produce a much lighter rate of runoff at the central point in a given time than would a long, narrow watershed of the same size, unless the storm duration was of sufficient length to satisfy the time of concentration on both watersheds. Inasmuch as very often the convective type of storm does not last sufficiently long to satisfy this time, it is obvious that the larger the area lying within a given radius from the point of outlet, all other things being equal, the higher the rate of runoff.

Soil Types:

The soil type peculiar to a given watershed is primarily felt as it influences infiltration rates. It is of course obvious that a higher infiltration capacity allows the percolation of greater percentages of rainfall during a given time and consequently less surface runoff occurs. Attempts have been made, and at times successfully, to establish the infiltration rate of the soil present on a given watershed and modify runoff coefficients on this basis. This may be feasible when exhaustive surveys of an area are to be made; however, the complexity of soil types within this Region make it impossible to attempt a delineation of any areas or zones as having high or low infiltration rates. When it is considered that even within the limits of one watershed there may be present many different soil types, each of which should theoretically be assigned an infiltration rate, it becomes obvious that no concise recommendation can be made.

The futility of attempting to assign infiltration rates to general areas or sections of the Region becomes more obvious when it is realized that the capacity of a given soil is materially influenced by the amount of moisture present when the flood-producing rainfall occurs. The frequency of high runoff then becomes not necessarily a rainfall frequency but one of flood flow magnitude as it occurs with relation to antecedent precipitation. Runoff records from experimental watersheds show the profound influence of soil moisture on runoff, and it is likely that this influence may more often than not be of greater consideration than the soil type itself. Thus, even with a consistent soil type over the area the maximum runoff still may depend more upon antecedent rainfall. In view of constant

variations of rainfall intensities and other characteristics pertinent to investigations of probable maximum discharges it does not appear logical to consider the soil type prevalent on a given watershed as of the major importance unless it varies exceptionally from general or average conditions. There are certain instances, however, in which soils conditions should play a predominating part in the consideration of flood flows.

For example, an area having very sandy soil to some depth throughout and not highly dissected is unlikely to produce high discharges even when subjected to excessive precipitation. Another possible influence on maximum rates of runoff is the presence of sandy tributary arroyos or one wide, sandy, principal waterway on a long, narrow watershed. Considering the infiltration rate of sand, it readily can be seen that a great deal of storm runoff may never reach the point of outlet.

The possibility of natural spreading within a given watershed also should be considered. Rough estimates made from data collected at Mexican Springs, New Mexico, indicate that a relatively flat and reasonably pervious spreading area of one-tenth the size of the more steeply sloping and rough tributary watershed may absorb a major portion or at times all runoff from the tributary area. In view of such occurrences, it is reasonable to expect the retention of a part or all runoff from certain tributaries to a watershed if natural water spreading areas are in existence.

Although many soils conditions are beneficial to the reduction of flood flows, still others have the opposite effect. Certain types of shales, for instance, on being wetted appear to form an almost water-tight seal on the ground surface and, as a result, infiltration rates may approach zero. The presence of these types, if suspected, should be determined by qualified soil scientists.

Vegetative Types:

The vegetative aspect of a given watershed must be considered in a similar manner as soil types. It is generally recognized that there are wide differences in the character and density of vegetation. In fir and spruce stands as well as in heavy oak brush there is not only the cushioning effect of considerable leafage but usually there is a mantle of highly absorptive duff on the ground. Contrast this with the sparsely vegetated areas in low rainfall regions. In between these two extremes is the country typified mostly by woodland (pinon and juniper), grassland and northern desert shrub (mainly sage) where the Service is principally engaged in assisting soil conservation districts. Within this large area, it is probable that the main difference in effectiveness of vegetation in retardation of runoff is caused by past or present grazing use.

Long-continued overuse of the range usually results in a thinned stand of herbaceous cover, the occurrence of inferior species and the establishment of a network of gullies - all of which promotes accelerated runoff. Even with an "about-face" in management it might take 5 to 10 years for vegetation to recover sufficiently to appreciably effect the rate of runoff. On the other hand, a range of similar environment may have been judiciously

managed in the past; all plants are vigorous and reasonably abundant; and drainage ways are not "gutted". For these reasons the watershed is functioning properly and flood probabilities should be somewhat less on such an area.

It is recognized that there is a great deal of fluctuation from year to year in the amount or seasonal occurrence of rainfall and that this naturally influences the amount of vegetative growth, even on ranges in very good condition. If, for example, a reduction in the runoff coefficient is made due to the presence of lush vegetation at a particular time, there is no guarantee that the same condition will exist when the flood-producing rain occurs. It is not at all true that high intensity rainfall occurs only during years of rainfall favorable to vegetative growth, and an early drouth period can easily discourage growth prior to the storm period. The effect of volume growth and interception of rainfall is greater as the growing season progressively moves forward; thus, during no periods of a growing season will volume growth have the same influence.

Considerable emphasis should be placed on the presence or absence of a heavy growth of vegetation such as sacaton, chamiza, etc., in tributary or principal waterways. Ordinarily the waterways will receive some concentration of runoff from outlying areas and even though precipitation may be far below normal during a given year a certain amount of growth will probably take place (due to carryover of soil moisture). Since comparatively deep alluvial soils are usually found in these swales, the combined effect of reduced velocity and increased infiltration may result in material reduction of flood flows.

It is realized that the above comments do not provide a formula for making even rough allowances for the vegetative factor in caluclating runoff. For the time being, experience in a given area will need to point the way. One thing stands out, however, and that is where outstanding differences in type of vegetation occur there are bound to be marked differences in rate and amount of runoff.

Amounts of Runoff from Rainfall--

The prevalence of spectacular erosion and the "flashy" nature of flood flows in the Southwest often has led toward the impression that considerable portions of the annual rainfall appear in the form of runoff.

Since 1939 the Research Division of the Soil Conservation Service has operated a number of experimental watersheds in Arizona, New Mexico, and Colorado. Inasmuch as the areas are small and the period of record covers one of the wettest years in recent history (1939), there is every reason to believe that the data are applicable to a large part of Region 6, where yields from rainfall runoff are of major consideration.

Extreme variations in total annual yields have occurred as would be expected. Regardless of such variations, however, one consistent fact has been outstanding; i.e., that runoff resulting from rainfall represents but a small fractional part of the annual precipitation. From 10 watersheds of 40 to 790 acres in size a total yield of 8% of the year's precipitation is considered very high and 5% or less is an average proportion. These data are in line with other runoff records, such as those of the U. S. Geological Survey, and can be considered as more or less representative of the lower-lying areas in Region 6. The technician therefore should keep in mind that runoff from watersheds due to storm rainfall will average less than 5% of the total annual precipitation. The data contained in table VII will be of assistance in determining probable amounts of runoff from certain areas within the Region.

Rates and Amounts of Runoff from Melting Snow--

The contrast between intensities of runoff from the high mountains and plains areas of Region 6 is directly reversed when consideration is given to water yields. Although unit runoff rates characteristically drop with major gains in elevation, the opposite is true with regard to total runoff. Whereas a 5% runoff may be considered average or above the average in the arid and semi-arid portion of the Region, a yield of 30% to 40% of the annual precipitation is not uncommon in the major snow storage areas.

The estimation of probable rates and amounts of runoff from melting snow requires an entirely different approach than that of runoff from storm rainfall. Obviously the formulae now in use for determination of maximum discharge cannot be applied to areas where flood flows from snow melt are of major consideration. In the absence of actual records from a given watershed the technician can best estimate the probable runoff by interpolation between watersheds from which the flows have been gaged. The erratic nature and peculiar distribution of snow storage make such interpolation difficult under the best condition. Several physiographic and other characteristics of a watershed however enter into a logical estimate of runoff. These are outlined and discussed below:

1. Precipitation characteristics
2. Exposure to sunshine
3. Exposure to wind
4. Vegetative characteristics
5. Geologic and soils characteristics
6. Topographic characteristics

Precipitation Characteristics--

Obviously the proportion of annual precipitation occurring in the form of snow is of first consideration. The predominating factors involved are of course latitude and elevation, which reflect the prevailing temperature. It must be kept in mind, however, that the time of occurrence of snowfall, when correlated with temperature and wind movements also is of consideration. On certain types of watersheds early and late snowfall may contribute nothing whatever to runoff due to quick melting, infiltration and

evaporation. The most complete information concerning annual snowfall can be found in publications of the U. S. Weather Bureau and particularly in their climatological summaries, the last of which includes data through 1930.

Exposure to Sunshine--

Although the amount and time of occurrence of snowfall is important, rates and amounts of runoff may vary widely between watersheds receiving the same catch. Areas located on the south and west slopes ordinarily receive much more sunshine than those to the north, with resulting higher temperatures. Such a situation promotes melting, evaporation, and infiltration to a much greater extent, with subsequently less storage.

Exposure to Wind--

The ability of wind to accelerate evaporation rates long has been recognized. As a result, watersheds located to the windward sides of mountains, all other things being equal, are likely to retain much less of the snow catch than those to the leeward. It also is possible that in certain cases the snow from the watersheds located near the top of divides may be blown over the ridge and deposited on adjacent areas. In the greater part of Region 6 prevailing winds are westerly.

Vegetative Characteristics--

The presence or absence of trees and other vegetative growth on a given watershed is of utmost importance in the consideration of snow storage. Not only are ground temperatures ordinarily lower if good vegetation is present but also wind movement is materially reduced. The importance of this factor is such that under certain conditions the difference in vegetative characteristics of two watersheds may have a greater influence than their exposures.

Geologic and Soils Characteristics--

The soil depth and type as well as the subsurface storage characteristics of a given watershed are reflected in its infiltration capacity. Obviously the greater opportunity for infiltration the less surface runoff.

Topographic Characteristics--

Variations in rates and amounts of runoff between watersheds are influenced to some extent by the degree and amount of dissection and the prevailing slopes. A broken area containing steep slopes is indicative of accelerated runoff rates and greater maximum rates of flow. On the other hand, the presence of deep narrow canyons within a watershed located to the windward and with a southern exposure is a definite asset due to the collection of drifted snow in the shaded portions.

The Probability of Rain on Snow--

The possibility of warm rains falling on snow with resultant flooding has remained uppermost in the minds of residents located along streams originating in snow storage areas. Undoubtealy in the eastern, central, and extreme western portions of the United States such fear is well grounded; however, the danger is materially less in Region 6 due to several climatological characteristics of the area.

Foremost of these is the normal preponderance of precipitation as it occurs either in the winter or summer months at the higher elevation. As has been outlined heretofore, the months of April, May, and early June are normally dry as compared with other seasons of the year and, although it is possible that within a given year heavy rains may occur during this period, the likelihood or frequency of occurrence is definitely minimized. If this is coupled with the necessity of having a heavy snow storage available for runoff at the time this particular rain occurs, the frequency becomes even less.

Another characteristic of the Region that tends to minimize the probability of heavy rains falling on snow cover is the normal incidence of snow cover only at high elevations and the location of such areas with respect to major movements of moist and comparatively warm air. Whereas the eastern, central, and extreme western portion of the United States are subject to heavy invasions of Tropical Gulf and Atlantic air masses in the first two cases and the Polar Pacific masses in the latter, the inland mountain ranges (Rockies, Wasatch) are exposed to these masses only after they have been cooled and considerable moisture has been removed. As a result the precipitation at the higher elevations where snow normally accumulates occurs in the form of snow rather than rainfall due to the prevailing low temperatures and the air mass characteristics. Perhaps the most likely area within the Region where rain on snow may produce the maximum discharge is in high mountainous areas of central Arizona. As mentioned heretofore, heavy winter and spring rainstorms do occur with some frequency in this Region.

Although the preponderance of precipitation in parts of western Utah occurs during winter and spring the latitude, elevation, and resulting low temperatures tend to minimize the probability of heavy flood flows resulting from rain on snow.

CONCLUSION

The preceding discussion, although somewhat lengthy, must still be considered as a very brief outline of climatological and hydrological characteristics and their influencing factors. Virtually any one of the major topics considered can be expanded to a point of equal or much greater length than the entire paper. To attempt a brief explanation of phenomena has been by far the most difficult task involved.

In summation it is thought advisable to outline the purpose of the discussion. They are as follows:

1. To acquaint the technician with the source and normal directional movement of the air masses that influence precipitation.

2. To briefly explain the causes, characteristics, and effects of the major storm types.

3. To show the influence of meteorological characteristics on the rainfall in various parts of the Region. In this connection the discrepancies in data outlined in U. S. D. A. Publication No. 204 are brought out.

4. To focus attention on the fact that rainfall characteristics of the high mountain areas are very different from those of semi-arid and arid sections.

5. To present certain thoughts and data concerning the temperature and evaporation characteristics of the Region.

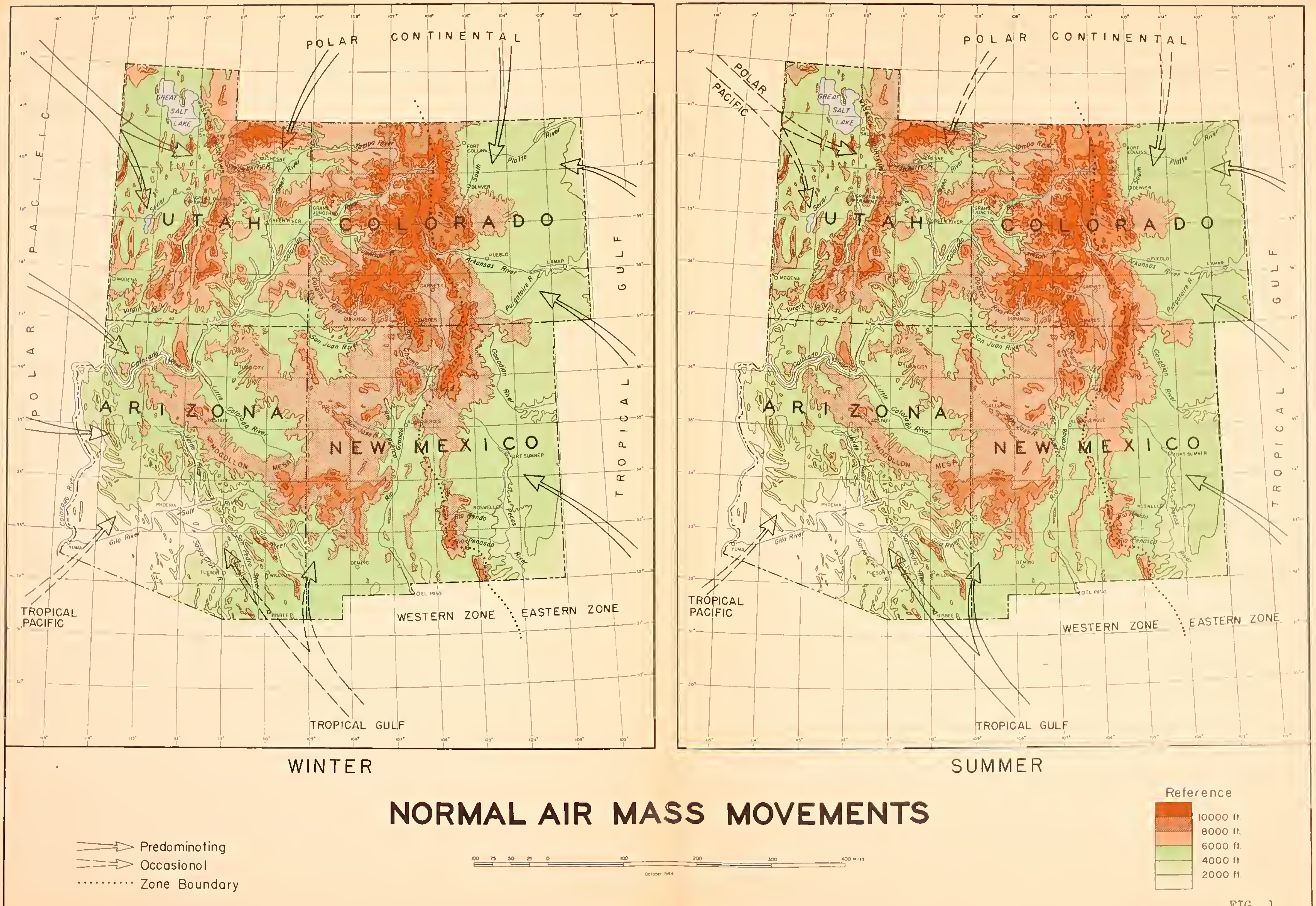
6. To outline the major factors involved in proper runoff determination and in some measure to acquaint the technician with the complexity of the runoff problem.

7. To bring out the characteristically low yields of water from semi-arid areas and the proportionately high runoff from watersheds at higher elevations.

8. To call attention to the fact that although amounts of runoff are much greater the unit runoff rates are far less from snow storage areas than from those in semi-arid sections.

It should be clearly understood that this discussion is provisional and subject to revision as additional information is collected. Certain parts and particularly those concerning rainfall intensities contain hitherto unpublished theories and supporting data. Technicians are invited to criticize any section of the paper and particularly to point out exceptions to the general theory. The Regional Engineering staff offers its assistance to field men whenever possible and as much as possible if runoff problems are submitted and are accompanied by adequate data.

Certain reports are forthcoming from the Research Division covering data collected during the last six to eight years at experimental watersheds in Colorado, western Texas, Arizona, and New Mexico. They will be transmitted to the field as further guides in estimating runoff. Meanwhile the Engineering and Research Divisions will continue to collect available data and study the runoff problem with the purpose of progressively adding to and improving the quality of information now on hand. In this connection the field technician can be of major assistance by advising the Regional office of all unusual storms, as was requested in Mr. Boyle's memorandum of June 30, 1944.



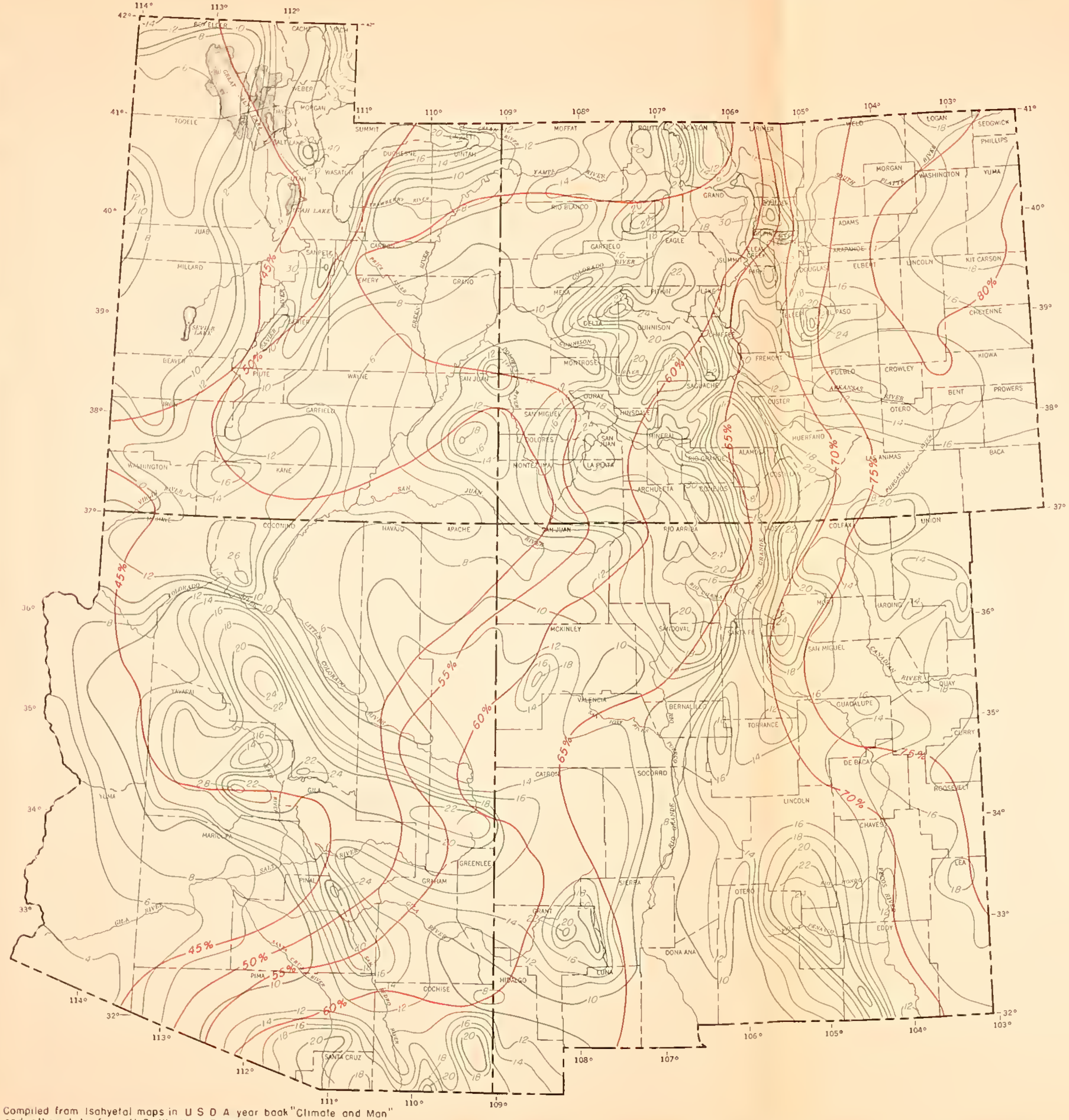
NORMAL AIR MASS MOVEMENTS

FIG. 1

SOIL CONSERVATION SERVICE

SOUTHWEST REGION

U S DEPARTMENT OF AGRICULTURE



LEGEND

—12— Average Annual Precipitation in inches.

—50%— Percentage of Annual Precipitation April — September inclusive.

AVERAGE ANNUAL AND SEASONAL PRECIPITATION SOUTHWEST REGION

Albuquerque, New Mexico

50 0 50 100 150

Scale in Miles

February 13, 1945

Compiled from Isohyetal maps in U S D A year book "Climate and Man" and other data from U.S. Weather Bureau.

FIG. 2

SOIL CONSERVATION SERVICE WASHINGTON D C
MARCH 1945 1303

TABLE I

RELATION OF AIR MASS MOVEMENT TO QUANTITY AND DISTRIBUTION OF PRECIPITATION
REGION 6

Station	Period of Record (Yrs.)	Elevation	Average Annual	Average Seasonal	% of Annual	Remarks
Arizona						
Bisbee	53	5,350	19.15	12.18	64	Located at abrupt rise in path of heavy invasions of Gulf air, also subject to winter invasions from Pacific. Elevations sufficient to induce precipitation.
Flagstaff	52	6,907	21.17	10.07	48	High elevation, frequent interception of both Gulf and Pacific air masses.
Tuba City	41	4,593	6.86	3.54	52	Similar to Grand Junction, Colorado, except no barriers in vicinity and somewhat less influenced by Pacific air.
Yuma	74	138	3.47	1.19	34	At very low elevation and west of principal Gulf air movement, winter masses override.
Colorado						
Cumbres	37	10,015	29.86	11.35	38	Elevation and location such that both Gulf and Polar Pacific air frequently intercepted. More interception during winter than low-lying areas.
Denver	72	5,221	14.05	9.75	69	Similar to Lamar, somewhat farther from Gulf air mass sources in normal direction of movement.
Garnet	40	7,576	6.88	5.14	75	Almost completely surrounded by 10,000-foot mountains. Far removed from Polar Pacific air mass source. Virtually no winter precipitation.
Grand Junction	54	4,668	8.83	4.74	54	Far removed from moisture sources, much interception between. Comparatively low elevation.
Lamar	55	3,615	16.05	12.22	76	Subject to frequent invasions of Gulf air moving inland, predominately moist during spring and summer.

Table I (Cont'd)

Station	Period of Record (Yrs.)	Elevation	Average Annual	Average Seasonal	% of Annual	Remarks
New Mexico						
Deming	68	4,331	9.00	5.86	65	Closer to source of Gulf air than Gallup but much lower. Higher percentage in summer but less total.
Fort Sumner	42	4,028	17.03	11.60	68	Subject to frequent invasions of moist Gulf air particularly during summer months.
Gallup	25	6,785	11.77	6.91	59	Elevation sufficient to encourage precipitation but located farther from Gulf air sources.
Santa Fe	94	7,000	14.27	9.45	66	Similar to Ft. Sumner except located to west of Sangre de Cristo Mountains.
Utah						
Duchesne	38	5,520	9.49	5.51	58	In Uintah Basin with topographic barriers surrounding. Receives more Pacific moisture than Grand Junction.
Great Basin Expt. Station	17	8,700	29.31	11.98	41	Elevation and location such that both Gulf and Pacific masses frequently intercepted. Pacific air predominates.
Greenriver	45	4,087	6.24	3.49	56	Similar to Grand Junction, Colorado and Tuba City, Arizona
Modena	43	5,460	10.14	5.15	51	In path of Gulf air invasions. Moderate elevation reduces total precipitation.
Salt Lake City	70	4,260	16.13	7.12	44	Little influenced by Gulf air. Location with respect to Pacific air mass movements and surrounding topographic characteristics promotes heavy winter and spring precipitation.

TABLE II

INTENSITY FREQUENCY OF PRECIPITATION
REGION 6 AND VICINITY

Station	15 minutes			30 minutes			60 minutes			120 minutes		
	10 yrs	25 yrs	50 yrs	10 yrs	25 yrs	50 yrs	10 yrs	25 yrs	50 yrs	10 yrs	25 yrs	50 yrs
Eastern Zone												
Colorado												
Denver	1.09	1.39	1.56	1.30	1.66	1.96	1.65	2.15	2.55	1.82	2.34	2.75
Pueblo	0.92	1.07	1.19	1.32	1.60	1.81	1.61	1.98	2.25	1.74	2.10	2.39
Kansas												
Dodge City	1.40	1.63	1.80	1.99	2.35	2.61	2.76	3.31	3.75	3.37	4.07	4.63
Nebraska												
North Platte	1.18	1.44	1.64	1.65	2.01	2.29	2.51	3.04	3.46			
New Mexico												
Roswell	1.05	1.24	1.38	1.44	1.66	1.84	1.79	2.12	2.36	2.23	2.69	3.05
Texas												
Amarillo	1.22	1.45	1.58	1.84	2.11	2.32	2.25	2.59	2.83	2.83	3.32	3.69
Wyoming												
Cheyenne	1.11	1.32	1.48	1.41	1.69	1.89	1.64	1.99	2.24	1.72	2.06	2.32
Western Zone												
Arizona												
Phoenix	0.74	0.89	1.00	1.05	1.27	1.43	1.31	1.57	1.78	1.64	2.04	2.36
Tucson	1.05	1.29	1.47	1.40	1.73	2.00	1.61	1.96	2.22	1.78	2.14	2.43
Colorado												
Grand Junction	0.49	0.58	0.65	0.63	0.74	0.82	0.73	0.84	0.93			
Wagon Wheel Gap	0.55	0.65	0.73	0.66	0.76	0.83	0.77	0.87	0.95	0.95	1.09	1.20
New Mexico												
Albuquerque	0.78	0.90	0.99	1.05	1.24	1.38	1.41	1.69	1.90	1.57	1.92	2.17
Santa Fe	0.73	0.83	0.91	0.99	1.15	1.27	1.23	1.47	1.64	1.47	1.76	1.99
State College	0.77	0.92	1.02	1.06	1.25	1.39	1.30	1.58	1.81	1.48	1.76	2.00
Texas												
El Paso	0.86	1.02	1.14	1.10	1.29	1.43	1.40	1.69	1.91	1.55	1.85	2.08
Utah												
Alpine	0.49	0.59	0.67	0.70	0.85	0.97	0.85	1.04	1.19			

TABLE II (Cont'd)

Station	15 minutes			30 minutes			60 minutes			120 minutes		
	10 yrs	25 yrs	50 yrs	10 yrs	25 yrs	50 yrs	10 yrs	25 yrs	50 yrs	10 yrs	25 yrs	50 yrs
Modena	0.71	0.87	1.00	1.02	1.27	1.46	1.32	1.66	1.93	1.45	1.77	2.03
Salt Lake City	0.60	0.70	0.79	0.75	0.90	1.03	0.84	1.03	1.17	0.95	1.11	1.24
Wyoming												
Leander	0.75	1.00	1.23	0.89	1.19	1.43	1.01	1.29	1.51	1.12	1.36	1.54
Idaho												
Pocatello	0.64	0.76	0.86	0.84	1.01	1.14	1.00	1.21	1.38	1.08	1.28	1.44

TABLE III
AVERAGE MONTHLY AND ANNUAL TEMPERATURE
REGION 6

Station	Length of Record (Years)	Elevation	Mean Temperatures ° Fahrenheit												
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
ARIZONA															
Ajo	29	1,770	52.2	56.2	61.6	68.5	76.5	85.6	89.7	87.7	83.9	73.1	61.8	54.3	70.9
Ashfork	28	5,160	35.4	39.4	44.6	51.0	58.5	68.8	74.1	72.2	66.2	55.8	45.2	38.3	54.1
Benson	62	3,523	46.4	50.0	55.2	62.3	71.5	80.0	82.9	80.1	75.3	64.8	54.4	47.4	64.2
Bisbee	51	5,425	46.0	48.5	53.2	59.7	67.2	76.1	75.3	74.1	71.2	62.9	53.3	45.5	61.2
Chinlee	25	6,090	28.0	34.0	41.4	49.0	58.4	68.5	74.1	72.1	63.8	51.8	39.3	29.8	50.8
Douglas	40	3,973	45.5	49.4	54.6	59.5	68.2	77.5	79.9	77.9	74.1	64.0	52.8	45.9	62.4
Flagstaff	52	6,907	27.3	30.7	36.5	43.3	50.5	57.8	65.7	64.0	57.2	45.9	37.2	29.6	45.7
Gila Bend	48	737	52.9	56.9	63.1	69.5	77.3	87.3	93.3	91.4	85.5	73.7	61.9	53.2	72.2
Globe	41	3,440	44.0	47.8	53.4	60.0	68.1	72.8	78.8	80.4	74.9	63.7	52.3	44.4	62.4
Holbrook	51	5,069	32.4	39.6	45.9	53.3	61.3	70.5	76.3	75.0	67.8	55.5	43.4	34.1	54.6
Jerome	44	5,250	42.0	44.9	50.3	57.5	65.6	76.2	79.1	76.5	72.1	62.1	51.8	43.6	60.2
Kayenta	25	5,800	27.7	36.3	43.8	51.9	61.5	71.0	75.8	73.6	66.0	54.0	40.6	31.4	52.8
Kingman	39	3,326	43.4	46.7	51.5	58.5	65.7	70.4	82.3	80.2	73.7	62.5	52.1	43.8	61.4
Leupp	16	4,150	29.8	38.5	45.3	53.6	60.5	70.9	76.9	75.3	67.0	55.1	41.1	33.6	54.0
Mohawk	38	538	54.5	59.2	65.4	71.7	79.7	89.8	94.7	92.9	87.4	75.9	63.9	55.6	74.2
Natural Bridge	29	4,990	40.8	44.0	48.8	55.0	62.5	72.0	76.3	74.3	69.4	59.6	49.5	42.9	57.9
Nogales	36	3,839	46.8	49.9	54.1	60.6	67.8	80.7	80.2	77.6	73.9	64.5	55.0	48.0	63.0
Phoenix	48	1,108	51.3	55.1	60.7	67.0	75.0	84.5	89.8	88.5	82.7	70.6	59.7	52.0	69.7
Prescott	77	5,389	34.9	38.1	43.7	50.3	58.2	67.6	72.5	70.8	64.4	53.9	43.6	35.4	52.9
Quartzsite	27	871	49.6	54.8	61.4	69.6	78.2	87.4	94.0	92.1	85.1	71.5	58.7	49.9	71.0
Safford	44	2,900	44.3	48.7	54.2	60.7	68.8	78.4	83.1	80.7	74.8	63.4	52.0	44.6	62.6
Salome	35	1,775	48.4	51.7	57.1	63.6	71.3	81.2	88.0	85.5	79.9	67.9	57.1	49.5	66.8
San Simon	33	3,609	44.7	49.2	55.6	63.7	72.8	80.3	83.8	82.0	76.5	65.6	54.9	46.9	64.7
Springerville	30	6,862	31.2	34.7	39.4	46.5	54.4	63.3	66.5	64.3	59.1	50.6	40.2	33.0	48.6
Truxton	25	3,997	38.6	44.4	49.9	56.2	63.4	73.2	79.9	77.8	71.4	60.9	50.2	41.5	59.0
Tuba City	40	4,500	32.2	39.0	46.5	54.0	62.4	71.8	77.5	75.7	68.3	56.1	43.5	33.4	55.0
Tucson	73	2,423	49.2	52.2	57.7	64.4	73.2	82.6	86.4	84.2	79.6	68.7	57.7	50.7	67.2
Yuma	66	141	54.4	58.6	64.1	69.5	76.2	84.7	90.8	90.4	83.7	73.3	62.4	55.2	71.9

TABLE III (Cont'd)

Station	Length of Record (Years)	Elevation	Mean Temperatures ° Fahrenheit Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
COLORADO															
Burlington	54	4,250	27.9	32.0	39.2	48.2	58.0	67.9	74.4	73.1	65.0	52.8	39.7	29.7	50.9
Cheyenne Wells	51	4,250	28.5	31.3	39.1	49.2	58.6	69.1	75.0	73.7	65.3	53.0	39.9	30.0	51.0
Collbran	42	6,200	21.9	27.8	36.5	45.7	53.9	62.8	68.8	66.9	57.4	47.4	35.3	23.8	45.6
Colorado Springs	65	6,098	28.9	31.9	37.6	45.4	54.3	63.9	68.5	67.1	59.9	49.2	38.1	30.7	47.9
Del Norte	25	7,868	19.9	26.2	34.2	42.2	50.9	58.4	62.8	61.3	55.2	46.0	33.1	23.0	42.8
Delta	53	4,965	24.2	32.1	41.6	50.7	59.5	68.1	74.1	71.7	63.1	50.9	37.6	26.2	50.0
Denver	72	5,292	29.8	32.7	39.3	47.1	56.2	66.3	72.2	70.7	62.9	51.2	39.8	32.3	50.0
Durango	50	6,550	24.5	29.8	37.4	45.1	52.6	61.0	66.9	65.8	58.6	48.0	36.7	26.6	46.1
Fort Collins	65	5,003	26.0	27.8	36.2	45.7	54.6	64.1	69.2	68.0	59.5	48.1	35.9	27.9	46.9
Fort Morgan	47	4,321	23.3	28.3	36.7	46.8	56.4	66.8	73.0	70.8	61.6	49.3	36.0	25.1	47.8
Fruita	44	4,525	22.5	31.2	42.3	51.1	59.9	69.1	75.6	73.3	62.5	51.0	37.8	26.0	50.2
Glenwood Springs	42	5,823	23.4	28.6	37.7	46.4	54.8	62.5	68.5	67.1	59.4	48.6	35.9	25.8	46.4
Grand Junction	53	4,668	24.0	32.9	43.6	52.4	61.5	71.4	77.7	74.2	66.2	52.8	39.3	27.5	53.0
Grover	34	5,076	25.1	28.1	34.9	44.0	53.3	63.7	70.5	68.5	60.2	48.6	35.3	27.0	46.7
Gunnison	50	7,683	7.6	13.7	26.0	39.5	48.0	56.0	61.5	59.8	52.3	41.4	27.7	12.5	37.2
Hayden	26	6,337	16.7	20.9	29.5	41.7	50.9	60.0	66.4	64.5	53.4	45.4	31.1	20.2	41.7
Holly	42	3,385	30.5	34.5	43.2	52.8	62.4	72.6	77.9	76.4	68.6	56.1	41.8	31.2	54.0
Holyoke	32	3,745	27.0	27.9	36.1	47.6	57.7	67.7	75.1	72.7	63.7	51.3	37.1	28.7	49.6
Ignacio	30	6,884	22.0	28.4	36.6	44.7	52.8	61.8	67.9	65.9	58.9	47.7	35.4	26.1	45.7
Lamar	53	3,615	30.8	34.9	44.1	53.6	63.1	73.6	78.7	77.3	67.7	55.7	42.0	31.7	54.4
Las Animas	75	3,982	27.3	32.9	42.0	51.9	62.3	72.5	77.6	75.2	66.4	53.5	38.9	29.7	52.5
Limon	33	5,360	26.4	30.1	36.7	45.1	54.6	64.9	70.6	68.8	61.2	49.8	37.2	27.4	47.7
Montrose	50	5,830	24.0	31.2	39.6	48.0	56.7	66.1	71.4	69.0	61.3	49.5	36.6	26.2	48.3
Monument	33	7,200	26.7	28.6	33.4	41.1	50.4	60.1	66.0	64.1	57.1	46.5	35.8	28.6	44.9
Palisades	30	4,740	22.5	31.2	42.3	51.1	59.9	69.1	75.6	73.3	62.5	51.0	37.8	26.0	50.2
Pueblo	68	4,808	28.7	32.1	40.8	49.4	58.9	68.6	74.2	72.7	64.6	51.2	38.3	30.1	50.8
Rocky Ford	55	4,177	29.2	33.3	41.6	51.6	60.9	70.5	75.5	73.9	64.4	53.5	39.7	30.1	52.0
Saguache	48	7,800	19.2	25.8	34.5	42.9	51.1	59.6	63.1	59.9	56.1	45.7	33.1	21.1	42.7
Spicer	31	8,300	17.0	20.3	25.3	35.2	43.8	53.0	59.2	56.9	49.3	38.9	27.6	18.0	37.0
Sterling	34	3,939	24.1	29.5	37.3	47.6	57.1	67.3	73.1	71.0	62.3	50.3	36.9	25.3	48.5
Trinidad	42	6,300	33.6	36.0	41.9	49.3	58.1	67.2	71.8	70.2	63.8	53.4	41.9	33.9	51.8
Two Buttes	46	4,100	31.5	33.7	41.8	51.7	61.1	71.5	75.5	75.6	67.8	55.3	42.3	32.6	53.4
Westcliffe	40	7,860	24.2	26.4	33.6	41.2	49.7	58.8	63.0	61.7	55.1	44.5	33.1	24.9	43.0
Wray	47	3,512	28.2	30.4	39.5	49.2	58.9	69.2	75.3	73.2	64.4	52.3	39.0	29.1	50.7

TABLE III (Cont'd)

Station	Length of Record (Years)	Elevation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
			Mean Temperatures ° Fahrenheit												
					NEW MEXICO										
Agricultural College	83	3,863	40.8	44.8	51.2	58.7	65.2	77.7	78.9	77.4	71.2	60.2	48.5	40.6	59.4
Albuquerque	42	5,196	34.1	40.5	45.9	54.0	63.3	72.6	76.7	73.9	67.9	56.6	43.3	34.5	55.3
Alamogordo	5	4,250	42.3	47.2	52.6	61.2	68.5	77.6	79.6	77.8	72.5	62.5	50.2	43.6	61.6
Artesia	36	3,350	41.3	45.9	52.7	60.4	68.8	77.2	79.6	78.3	73.2	61.3	48.9	40.9	60.6
Capitan	13	6,348	29.6	34.5	40.8	48.2	56.3	64.1	67.8	65.9	59.8	49.9	37.0	32.4	49.0
Chama	43	7,851	21.6	24.9	31.2	40.1	48.6	57.7	63.5	62.3	55.8	46.0	34.7	24.5	42.6
Cimarron	38	6,427	32.3	35.2	40.9	48.2	55.9	64.8	68.8	67.5	61.4	51.7	40.5	32.8	50.0
Clayton	38	5,054	34.0	37.3	43.0	51.4	60.1	70.0	74.3	72.8	66.0	54.8	43.2	34.8	53.4
Cloudcroft	42	8,650	30.2	32.0	36.8	42.9	50.2	58.3	59.7	58.4	53.9	46.9	37.2	30.7	44.8
Clovis	32	4,262	36.8	41.4	47.0	56.7	66.0	74.9	78.9	77.0	69.8	55.9	46.0	38.1	57.5
Crownpoint	29	6,800	28.9	35.0	40.9	48.2	57.1	67.7	71.4	69.6	63.4	52.5	40.1	32.0	50.6
Elephant Butte	46	4,265	40.5	45.4	51.7	59.0	67.6	76.9	79.1	77.3	71.5	61.3	48.6	40.4	59.9
Espanola	35	5,590	29.3	35.0	42.8	50.4	58.8	67.9	72.2	71.0	64.6	52.4	39.6	29.6	51.1
Estancia	25	6,100	30.1	34.8	41.5	49.0	56.9	65.0	69.1	68.6	61.4	50.1	39.7	30.5	49.7
Fort Sumner	34	4,028	37.8	42.5	49.2	57.2	65.9	76.0	78.8	77.2	70.3	58.4	46.4	38.0	58.2
Fort Wingate	18	6,997	32.6	35.4	40.8	47.9	55.5	65.5	70.0	68.2	61.9	51.3	41.6	32.5	50.3
Hobbs	23	3,600	40.7	45.8	51.9	59.8	68.8	77.2	79.3	77.9	71.8	61.1	49.1	41.8	60.4
Hope	22	4,000	41.9	46.1	51.7	59.6	67.3	75.1	77.4	76.2	70.7	61.1	48.9	42.6	59.9
Laguna	29	5,840	33.1	37.8	44.7	52.3	60.8	70.4	74.0	72.7	65.9	54.4	42.3	33.3	53.5
Las Vegas	57	6,400	32.4	34.9	41.0	48.6	57.5	65.5	69.0	67.6	61.2	50.6	40.3	32.8	50.1
Magdalena	33	6,556	33.2	37.3	42.9	49.4	58.6	68.5	70.8	68.7	62.7	52.9	41.5	33.1	51.6
Mosquero	17	5,550	33.0	36.2	42.0	50.4	58.6	68.3	72.4	69.8	63.3	53.4	40.6	33.7	51.8
Mountainair	32	6,475	31.7	35.4	43.1	49.2	57.0	66.7	70.5	68.7	62.7	51.3	39.6	32.5	50.6
Portales	35	4,004	36.8	40.9	47.9	55.5	64.9	73.9	77.0	75.7	68.8	58.1	45.4	37.6	56.9
Quemado	16	6,600	28.0	36.1	37.7	44.6	52.4	62.2	66.2	63.8	59.0	49.8	37.7	29.0	47.2
Raton	6	6,660	30.6	32.5	40.0	47.1	55.8	64.8	69.0	67.5	60.8	50.3	40.1	30.5	49.1
Regina	28	7,450	23.0	28.2	34.6	43.7	51.0	61.2	65.7	63.9	56.8	46.2	34.9	25.2	44.6
Roswell	50	3,602	39.2	42.5	50.7	60.6	69.4	76.3	78.9	76.6	69.0	59.5	48.1	41.2	59.6
Santa Fe	68	7,013	29.3	33.1	39.6	47.1	55.8	65.4	68.9	67.6	61.2	50.5	39.1	31.0	49.0
Santa Rosa	31	4,624	38.8	42.3	49.1	57.2	65.5	75.0	77.8	76.1	69.4	58.3	47.1	38.9	58.0
Socorro	53	4,600	37.4	43.0	49.9	57.8	65.7	75.1	77.7	75.9	69.1	58.2	45.7	36.6	57.7

TABLE III (Cont'd)

Station	Length of Record (Years)	Elevation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
			Mean Temperature ° Fahrenheit												
			New Mexico (cont'd)												
Springer	49	5,857	29.9	33.1	40.8	49.3	58.5	67.1	70.9	69.0	62.3	50.9	38.9	30.4	50.1
Taos	46	6,893	25.3	31.5	38.9	46.9	55.2	64.0	68.0	66.7	60.1	49.1	37.4	26.7	47.5
Tucumcari	39	4,200	38.0	41.2	48.8	56.7	65.3	75.3	79.0	77.5	71.0	59.3	46.7	38.1	58.1
			UTAH												
Bluff	27	4,200	27.7	38.9	46.1	54.8	64.7	73.9	79.6	76.6	67.9	55.4	42.5	28.5	54.7
Cedar City	38	5,805	31.1	35.0	40.5	48.0	56.7	67.2	73.5	71.1	63.3	51.6	41.1	30.9	50.8
Duchesne	38	5,520	15.0	23.2	35.1	45.1	53.2	61.3	68.4	66.3	57.5	45.9	32.4	17.8	43.4
Escalante	34	5,700	25.3	32.1	39.1	46.7	54.8	64.6	69.7	67.5	59.3	49.2	38.3	27.0	47.8
Fillmore	52	5,250	29.2	34.3	41.5	49.8	58.4	68.4	76.0	74.6	65.0	52.7	41.1	29.3	51.7
Government Creek	43	5,277	26.3	30.8	37.9	46.1	54.2	64.2	73.5	71.8	61.4	49.3	37.8	27.0	48.4
Greenriver	43	4,087	22.2	33.6	44.1	53.3	62.6	72.2	79.4	76.4	66.2	52.3	38.6	25.0	52.2
Hanksville	30		22.3	33.9	43.7	52.6	61.3	71.2	77.6	73.0	64.1	51.7	38.9	27.1	51.4
Heber	51	5,559	20.9	25.0	34.3	44.1	52.1	60.0	66.4	64.9	55.9	45.9	35.1	22.5	44.0
Kanab	33	4,925	32.3	37.6	43.4	50.4	58.0	67.2	73.6	71.7	63.9	53.6	43.5	32.3	52.3
Laketown	43	5,988	21.0	21.8	29.1	40.5	49.7	57.8	65.3	63.5	54.2	43.6	33.1	23.7	41.9
Loa	40	7,000	21.2	25.5	32.9	41.3	49.8	59.3	65.7	62.7	53.4	42.2	31.7	20.6	42.2
Logan	52	4,507	23.7	27.6	36.4	47.2	55.2	64.0	72.4	71.1	61.4	49.7	37.4	25.1	47.6
Midvale	32	4,365	27.1	34.1	41.0	49.4	58.5	67.2	75.0	72.9	62.9	51.2	39.6	28.7	50.6
Milford	35	4,962	26.3	32.9	40.5	47.9	56.8	65.8	73.5	70.9	61.1	49.2	37.6	27.8	49.3
Moab	54	4,000	28.5	36.6	46.4	55.1	63.9	72.6	78.1	75.6	66.8	54.3	39.1	30.4	54.2
Modena	43	5,460	26.7	31.0	38.2	46.0	53.5	63.3	70.6	69.2	60.0	48.0	36.4	28.1	47.6
Monticello	30	7,000	23.1	28.9	35.0	44.7	51.6	61.6	66.9	65.5	58.0	48.3	36.7	24.9	45.4
Morgan	37	5,068	22.3	27.3	35.5	44.6	52.8	60.6	67.9	66.5	57.0	46.4	35.3	22.7	44.9
Panguitch	29	6,700	20.1	27.0	33.6	41.0	48.8	57.5	63.3	61.1	53.2	43.4	32.7	22.2	42.0
Richfield	46	5,300	27.5	32.7	40.6	47.8	55.8	63.9	71.0	68.7	59.6	49.1	38.0	27.9	48.5
Salt Lake City	70	4,260	29.2	33.8	41.7	49.6	57.4	67.4	75.7	74.5	64.4	52.5	41.1	31.9	51.6
St. George	55	2,880	37.9	43.3	50.2	58.0	67.1	76.5	82.6	80.9	71.8	59.6	47.5	38.0	59.4
Snowville	37	4,550	22.8	27.3	35.6	45.0	51.0	60.9	68.8	67.4	57.0	46.4	35.9	24.7	45.2
Tooele	47	4,820	28.6	32.8	40.1	48.4	56.4	66.4	74.4	72.8	63.3	50.9	39.7	29.2	50.3
Tremonton	27		21.5	28.9	36.9	47.7	56.9	66.0	75.1	72.9	62.8	49.5	36.8	24.5	48.3
Tropic	31	6,296	27.8	31.0	38.6	45.0	52.2	61.6	67.4	64.8	57.7	48.1	38.2	28.5	46.8
Vernal	42	5,335	16.8	23.3	35.4	47.0	55.2	64.7	70.3	68.0	58.5	46.2	34.4	18.4	44.9

TABLE IV

FROST FREE PERIODS
REGION 6

ARIZONA

Station	Length of Record (Years)	Elevation	Ave. Date Last Killing Frost Spring.	Ave. Date First Killing Frost Fall	Ave. Length Growing Season (Days)
Ajo	13	1,770	Feb. 3	Dec. 10	310
Ashfork	19	5,160	May 10	Oct. 15	158
Benson	30	3,523	Mar. 25	Nov. 9	229
Big Springs	9	6,600	June 13	Sept. 28	107
Bisbee	34	5,425	Mar. 24	Nov. 23	244
Chandler	18	1,213	Mar. 21	Nov. 17	241
Chinlee	18	6,090	May 27	Oct. 3	129
Douglas	27	3,973	Apr. 8	Nov. 7	213
Duncan	6	3,642	May 13	Oct. 14	154
Flagstaff	37	6,907	June 1	Sept. 28	119
Gila Bend	27	737	Feb. 12	Dec. 3	294
Globe	29	3,440	Mar. 26	Nov. 17	236
Holbrook	42	5,069	May 4	Oct. 16	165
Jerome	34	5,250	Mar. 29	Nov. 22	238
Kayenta	16	5,800	May 2	Oct. 13	164
Keams Canyon	19	6,600	May 19	Sept. 29	133
Kingman	29	3,326	Apr. 13	Nov. 9	210
Lees Ferry	14	3,142	Mar. 23	Nov. 7	229
Leupp	10	4,150	May 6	Oct. 18	165
Mohawk	16	538	Jan. 26	Dec. 11	319
Mt. Trumbull	7	5,000	Apr. 22	Oct. 10	171
Natural Bridge	25	4,990	Apr. 17	Nov. 7	204
Nogales	24	3,839	Apr. 3	Nov. 11	222
Patagonia	8	4,044	Apr. 15	Oct. 24	192
Phoenix	36	1,108	Feb. 10	Dec. 3	296
Pinto	15	5,660	May 23	Oct. 12	142
Prescott	32	5,389	May 18	Oct. 8	143
Quartzsite	16	871	Mar. 13	Nov. 22	254
Salome	22	1,775	Mar. 14	Nov. 20	251
San Simon	19	3,609	Apr. 8	Nov. 7	213
Signal	14	1,652	Mar. 12	Nov. 22	255
Springerville	19	6,862	May 27	Oct. 1	127
Thatcher	26	2,800.	Apr. 11	Oct. 31	203
Truxton	16	3,997.	Apr. 24	Nov. 6	196
Tuba City	32	4,500.	Apr. 23	Oct. 19	179
Tucson	40	2,423.	Mar. 17	Nov. 20	248
Yuma	53	141.	Jan. 2	Dec. 25	357

COLORADO

Station	Length of Record (Years)	Elevation	Ave. Date Last Killing Frost Spring.	Ave. Date First Killing Frost Fall	Ave. Length Growing Season (Days)
Burlington	17	4,250	May 6	Oct. 7	154
Castle Rock	25	6,220	May 15	Sept. 23	131
Cheyenne Wells	27	4,250	May 5	Oct. 6	154
Collbran	29	6,200	May 24	Sept. 27	126
Colorado Springs	27	6,098	May 8	Oct. 1	146

Station	Length of Record (Years)	Elevation	Ave. Date Last Killing Frost Spring	Ave. Date First Killing Frost Fall	Ave. Length Growing Season (Days)
Del Norte	9	7,868	May 25	Sept. 25	121
Denver	25	5,292	May 15	Sept. 23	131
Delta	36	4,965	May 10	Sept. 29	142
Dolores	13	6,710	May 22	Sept. 28	129
Durango	35	6,550	May 25	Sept. 18	116
Fort Collins	28	5,003	May 8	Sept. 27	142
Fort Morgan	25	4,321	May 10	Sept. 30	143
Fruita	28	4,525	May 7	Oct. 6	152
Glenwood Springs	26	5,823	May 25	Sept. 22	120
Grand Junction	39	4,668	Apr. 16	Oct. 19	186
Grover	12	5,076	May 27	Sept. 17	113
Gunnison	37	7,670	June 24	Aug. 31	68
Hayden	12	6,337	June 14	Sept. 12	90
Holly	20	3,385	Apr. 28	Oct. 9	164
Holyoke	14	3,745	May 11	Sept. 26	138
Ignacio	17	6,884	June 7	Sept. 19	104
Lamar	27	3,615	Apr. 25	Oct. 10	168
Las Animas	30	3,982	Apr. 30	Oct. 6	159
Limon	15	5,360	May 15	Oct. 2	140
Montrose	38	5,830	May 8	Oct. 3	148
Monument	12	7,200	May 28	Sept. 18	113
Palisades	17	4,740	Apr. 27	Oct. 15	171
Pueblo	34	4,808	Apr. 27	Oct. 9	165
Rangely	12	5,050	May 26	Sept. 18	115
Rocky Ford	29	4,177	Apr. 29	Oct. 7	161
Saguache	30	7,800	May 28	Sept. 24	119
Salida	23	7,050	May 28	Sept. 17	112
Spicer	10	8,300	June 28	Aug. 30	63
Sterling	13	3,939	May 9	Sept. 30	144
Trinidad	18	6,300	May 6	Oct. 14	161
Two Buttes	28	4,100	May 2	Oct. 13	164
Westcliffe	25	7,860	June 10	Sept. 13	95
Wray	24	3,512	May 5	Oct. 4	152
NEW MEXICO					
Agricultural College	39	3,863	Apr. 8	Oct. 26	201
Albuquerque	34	5,196	Apr. 13	Oct. 26	196
Alamogordo	30	4,250	Apr. 7	Nov. 4	211
Artesia	23	3,350	Apr. 8	Oct. 29	204
Boaz	22	4,154	Apr. 22	Oct. 22	183
Capitan	16	6,348	May 7	Oct. 10	156
Chama	28	7,851	June 4	Sept. 21	109
Cimarron	27	6,427	May 8	Oct. 8	153
Clayton	25	5,054	Apr. 24	Oct. 18	177
Cloudcroft	27	8,650	May 12	Oct. 6	147
Clovis	18	4,262	Apr. 16	Oct. 28	195
Crownpoint	14	6,800	May 6	Oct. 16	163

Station	Length of Record (Years)	Elevation	Ave. Date Last Killing Frost Spring	Ave. Date First Killing Frost Fall	Ave. Length Growing Season (Days)
Elephant Butte Dam	34	4,265	Apr. 1	Nov. 8	221
Espanola	30	5,590	Apr. 29	Oct. 10	164
Estancia	20	6,100	May 14	Oct. 6	145
Fort Sumner	21	4,028	Apr. 13	Oct. 24	194
Fort Wingate	14	6,997	May 8	Oct. 2	147
Garfield	24	4,400	Apr. 11	Oct. 22	194
Hobbs	16	3,600	Apr. 11	Nov. 3	206
Hope	15	4,000	Apr. 8	Nov. 1	207
Laguna	16	5,840	Apr. 27	Oct. 14	170
Las Vegas	38	6,400	May 6	Oct. 7	154
Lordsburg	21	4,245	Mar. 21	Nov. 5	229
Luna Ranger Sta.	24	7,300	June 12	Sept. 20	100
Magdalena	22	6,556	May 2	Oct. 15	166
Mills	18	6,090	Apr. 28	Oct. 14	169
Mosquero	14	5,550	Apr. 23	Oct. 26	186
Mountainair	21	6,475	May 8	Oct. 9	154
Portales	20	4,004	Apr. 17	Oct. 20	186
Quemado	6	6,600	June 9	Sept. 24	107
Raton	34	6,660	May 8	Oct. 2	147
Regina	14	7,450	May 30	Sept. 23	116
Roswell	37	3,602	Apr. 11	Oct. 28	200
Santa Fe	56	7,013	Apr. 24	Oct. 19	178
Santa Rosa	26	4,624	Apr. 11	Oct. 26	198
Silver City	14	5,937	Apr. 26	Oct. 23	180
Socorro	34	4,600	Apr. 9	Oct. 21	195
Springer	34	5,857	May 9	Oct. 4	148
Taos	32	6,983	May 11	Oct. 3	145
Tucumcari	26	4,200	Apr. 18	Oct. 26	191
		UTAH			
Bluff	12	4,200	Apr. 15	Oct. 15	183
Castledale	31	5,500	May 30	Sept. 21	114
Cedar City	24	5,805	May 13	Oct. 4	144
Duchesne	25	5,520	June 1	Sept. 15	106
Escalante	24	5,700	May 19	Sept. 27	131
Fillmore	38	5,250	May 18	Sept. 27	132
Government Creek	30	5,277	May 30	Sept. 25	118
Greenriver	27	4,087	May 3	Oct. 6	156
Hanksville	19	4,200	May 9	Oct. 2	146
Heber	38	5,559	June 15	Sept. 16	83
Huntsville	16	5,100	June 8	Sept. 11	95
Kanab	20	4,925	May 19	Oct. 8	142
Laketown	30	5,988	June 15	Sept. 8	85
Loa	24	7,000	June 17	Sept. 6	81
Logan	35	4,507	May 12	Oct. 9	150
Midvale	19	4,365	May 23	Sept. 24	124

Station	Length of Record (Years)	Elevation	Ave. Date Last Killing Frost Spring	Ave. Date First Killing Frost Fall	Ave. Length Growing Season (Days)
Milford	22	4,962	May 20	Sept. 18	121
Moab	38	4,000	Apr. 25	Oct. 8	166
Modena	30	5,460	May 21	Sept. 29	131
Monticello	18	7,000	May 25	Oct. 1	129
Morgan	22	5,068	June 10	Sept. 7	89
Mt. Pleasant	12	5,900	May 18	Sept. 27	132
Nephi	18	5,119	May 23	Sept. 30	130
Panguitch	20	6,700	June 20	Sept. 8	80
Price	17	5,500	May 23	Sept. 28	128
Richfield	28	5,300	May 25	Sept. 18	116
Salt Lake City	56	4,260	Apr. 18	Oct. 19	184
St. George	36	2,880	Apr. 15	Oct. 18	186
Snowville	29	4,550	June 16	Sept. 10	86
Tooele	34	4,820	May 12	Oct. 12	153
Tremonton	16	4,322	May 15	Oct. 6	144
Tropic	21	6,296	June 4	Sept. 14	102
Vernal	30	5,335	May 26	Sept. 21	118

TABLE V

AVERAGE MONTHLY AND ANNUAL EVAPORATION
REGION 6

Station	Period of Record (Yrs.)	Elevation	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Land Pan Evaporation Rates (Inches)									
						ARIZONA									
Roosevelt	28	2,230	1.88	2.66	4.91	6.98	10.11	12.36	12.15	10.04	7.92	5.36	2.90	1.85	79.11
Sierra Ancha	9	5,100	1.80	2.20	4.41	6.73	9.02	9.12	9.10	8.74	7.42	5.72	3.40	2.12	69.79
Tucson	16	2,526	2.53	3.30	6.18	8.60	11.25	12.63	11.75	9.67	8.27	5.22	3.66	2.23	86.32
Yuma	24	191	4.05	5.06	8.25	10.67	13.97	15.27	16.60	14.56	11.58	8.35	5.45	3.94	117.75
						COLORADO									
Akron	31	4,650	--	--	--	5.06	6.63	8.09	9.56	8.35	6.39	--	--	--	--
Montrose	5	5,811	--	--	3.39	4.93	7.25	9.59	9.99	7.99	6.07	3.61	1.79	--	--
						NEW MEXICO									
Agric. College	27	3,909	2.99	4.39	7.60	9.74	11.64	12.70	11.63	10.01	8.15	6.09	3.76	2.64	91.33
Alamogordo Dam	6	4,305	2.85	3.19	7.80	9.95	12.22	13.37	12.84	11.91	9.31	6.90	4.31	2.96	97.62
Conchas Dam	8	4,244	3.09	4.11	7.50	9.87	11.81	13.47	12.76	12.21	9.34	7.06	4.41	2.61	98.31
Eagle Nest	15	8,250	--	--	--	5.40	7.62	9.26	7.65	6.77	5.83	4.57	--	--	--
Elephant Butte	29	4,576	2.90	4.50	7.94	10.60	13.53	14.99	12.73	11.16	8.96	7.25	4.34	2.91	101.80
El Vado Dam	9	6,796	--	--	--	5.74	10.17	11.02	9.34	8.09	6.45	4.57	2.20	--	--
Coronado Exp. Sta.	16	4,265	2.75	4.03	7.36	9.88	12.58	13.84	11.97	10.46	8.48	6.36	3.85	2.38	93.94
Lake McMillan	5	3,280	2.97	4.69	8.32	10.34	11.91	13.65	12.88	11.98	8.88	6.70	4.80	3.24	100.36
Las Vegas	5	6,500	--	--	--	7.38	9.52	9.86	8.22	7.69	6.97	4.78	3.56	--	--
Portales	10	4,004	2.73	3.96	7.37	9.12	10.35	12.31	12.08	11.01	8.34	6.26	4.42	3.02	90.97
						UTAH									
Bear River Refuge	5	4,280	--	--	--	--	--	10.56	11.69	10.93	7.16	--	--	--	--
Myton	11 - 25	5,030	--	--	--	--	8.32	9.62	9.25	7.84	5.88	3.54	--	--	--
Piute Dam	15 - 26	5,900	--	--	--	--	9.54	11.57	10.92	9.47	7.65	4.89	--	--	--
Salt Lake Airport	5	4,227	--	--	--	6.11	8.67	11.82	13.91	11.92	8.53	4.75	--	--	--
Utah Lake (Lehi)	21	4,497	--	--	--	5.97	8.84	10.34	10.94	9.74	7.03	4.05	--	--	--

TABLE VI

Maximum Observed and Estimated Floods
Region 6

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Maximum Discharge C.F.S.	C.F.S. Sq. Mi.
		ARIZONA			
Alder Creek	At Mouth		5.3	13200	2491
Trout Creek	" "		17	22460	1283
Talley Wash	Nr. Thatcher		8.7	10000	1153
Billingsley Wash	" "	3	3.4	3390	971
Exp. Watershed #2	Nr. Pima	6	1.1	1000	909
Pot Creek	At Mouth		5.5	4280	778
Bear Creek	" "		160	110000	689
Pinal Creek	Nr. Globe		30	13200	440
Big Spring Wash	At Mouth	3	16	5500	340
Squaw Creek	" "		37	12200	327
Devil Canon	" "		5.4	1670	309
E. Fork Dutch Blue Creek	At Alma Trail		6.0	1623	270
Lone Star Wash	At Mouth	3	14	3200	222
Peterson Wash	" "	3	26	4600	179
Cave Creek	Nr. Phoenix		200	25000	125
Sabina Creek	Nr. Tucson-	11	35	4100	117
Sonoita Creek	Nr. Patagonia	12	210	20000	95
Walnut Canon	Nr. Flagstaff		128	10496	82
Canon Diablo	Nr. Leupp		544	44608	82
Clear Creek	Nr. Winslow	13	607	50000	82
Granite Creek	Nr. Prescott	11	39	2900	74
Queen Creek	Nr. Florence		191	13200	69
San Pedro	At Charleston	7	1480	98000	66
Canon Padre	Nr. Diablo Junc.		180	10800	60
Eagle Creek	At Mouth		639	36000	56
Tonto Creek	Nr. Roosevelt	24	678	32000	47
Bright Angel Creek	Nr. Grand Canon	13	100	4400	44
Rillito Creek	Nr. Tucson	31	903	28000	31
Santa Cruz River	Nr. Nogales	12	542	12000	22
San Simon Creek	Nr. Solomonsville		2280	27500	12
San Simon Creek	Nr. Tucson	37	2190	15000	7
Moencopi Wash	Nr. Tuba City	16	2270	14100	6.2
		COLORADO			
Skyrocket Creek	Nr. Ouray		1.0	2000	2000
Cameron Arroyo	Nr. Pueblo		7.3	13900	1900
Missouri Canon	Nr. Masonville		2.4	4368	1820
Hogans Gulch	Nr. Eden		6.1	9638	1580
Shubarth Ranch	Nr. Littleton		.69	950	1377
Blue Ribbon Creek	Nr. Pueblo		6.7	9112	1360
Magpie Gulch	Nr. Golden		1.5	1905	1270
South Arroyo	Nr. Pueblo		1.8	1908	1060

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Maximum Discharge C.F.S.	C.F.S. Sq. Mi.
Rock Creek	Nr. Peublo		59	53867	913
Templeton Gap	Nr. Colo. Springs		7.1	6120	862
Granada Creek	Nr. Granada		40	31000	775
Middle Bijou	Nr. Peoria		151	71423	623
North Arroyo	Nr. Pueblo		16	9656	619
Boggs Creek	Nr. Pueblo		26	15132	582
Pecks Creek	" "		34	19402	562
Middle Bijou	Nr. Wilson Creek		151	71423	473
Dry Creek	Nr. Pueblo		86	24338	283
Brush Hollow Creek	Nr. Pueblo		22	5322	243
Rush Creek	" "		20	4665	238
Turkey Creek	" "		48	9024	188
Coal Creek	" "		22	3724	167
Eight-Mile Creek	" "		65	10010	154
St. Charles River	" "		482	71818	149
Horse Creek	Above Holly		155	22010	142
S. Fork Republican	Nr. Newton		669	82956	124
Chandler Creek	Nr. Pueblo		14	1605	118
Fred Rohr Gulch	" "		9.3	967	104
Arkansas (Florence to Pueblo)	" "		940	75200	80
Six-Mile Creek	" "		25	1894	77
North Crestone	Nr. Crestone	7	11	735	69
S. Boulder Creek	Nr. Eldorado Springs	48	114	7390	65
Purgatoire	Nr. Trinidad	24	742	45262	61
Bear Creek	Nr. Morrison	32	165	8600	52
La Plata	Nr. Hesperus	26	37	1880	51
Leroux Creek	Nr. Cedaredge	6	28	1310	48
Bear Creek	Nr. Morrison		180	8640	48
Rio Grande	Nr. Creede	34	163	7500	46
Pinos Creek	Nr. Del Norte	12	53	2400	45
Mineral Creek	Nr. Silverton	7	44	1700	39
Turkey Creek	Nr. Pagosa Springs	6	23	860	37
Animas River	Nr. Durango	41	692	25000	36
Fountain Creek	Nr. Fountain	4	676	22100	33
Plateau Creek	Nr. Colbran	21	88	2800	32
Animas River	Nr. Howardsville	6	24	650	30
Hannah Creek	Nr. Whitewater	24	55	1630	30
Fraser River	Nr. Winter Park	33	28	820	30
Roaring Fork	Nr. Aspen	20	109	3170	29
Meadow Creek	Nr. Tabernash	7	7.0	204	29
San Francisco Creek	Nr. Del Norte	7	13	364	28
N. Fork Ranch Creek	Nr. Fraser	6	4.4	124	28
Meadow Creek	Nr. Tabernash	6	7.0	197	28
Williams River	Below Steelman Creek	10	16	441	27
San Juan River	Nr. Pagosa Springs	6	41	1100	27
Rio Blanco	Nr. Pagosa Springs	8	58	1490	26
W. Mancos River	Nr. Mancos	5	42	1080	26

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Maximum Discharge C.F.S.	C.F.S. Sq. Mi.
S.Fork Ranch Creek	Nr. Frazer	6	2.5	59	23
Arapahoe Creek	At Monarch Lake	7	59	1380	23
Laramie River	Nr. Glendevy	32	101	2240	22
Ranch Creek	Nr. Frazer	5	3.8	85	22
East River	Nr. Almont	21	295	6500	22
Cherry Creek	Nr. Red Mesa	14	66	1480	22
Little Navajo River	Nr. Chromo	8	22	399	18
Ten-Mile Creek	Nr. Dillon	21	113	2010	18
Ranch Creek	Nr. Frazer	9	20	299	15
Vasquez Creek	Nr. Winter Park	11	26	396	14
Williams Fork	Nr. Parshall	29	184	2570	14
Michigan River	Nr. Lindland	10	62	663	11
Kerber Creek	In San Luis Valley	10	38	407	11
Trinchera Creek	Nr. Ft. Garland	10	45	478	11
Roaring Fork	Nr. Walden	19	84	790	9
Blue River	Nr. Dillon	32	129	1180	9
Colorado River	Nr. Glenwood Springs	43	4560	30100	7
Grape Creek	Nr. Westcliff	16	346	1960	6
Little Grizzly	Nr. Hebran	11	96	592	6
Peck Creek	Nr. Monte Vista	13	34	161	5
Grizzly Creek	Nr. Walden	17	252	1340	5
N. Platte River	" "	18	463	1940	4
Goose Creek	At Lake Cheesman	17	86	315	4
Taryall Creek	At Lake George	20	460	643	1.4

NEW MEXICO

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Maximum Discharge C.F.S.	C.F.S. Sq. Mi.
Arroyo (Unnamed)	Nr. Indiole		8.9	*9801	1101
Tom Moore Creek	Trib. to Gila		1.3	1040	820
Arroyo (Unnamed)	Nr. Santa Fe		3.2	1920	600
Santa Teresa Arroyo	Nr. Hatch		28	12000	429
Picacho Arroyo	Dona Ana County		9.6	4000	416
Canutillo	" " "		3.7	1500	405
Rio Galisteo	Nr. Domingo		689	24177	351
Angostura Arroyo	Dona Ana County		8.9	3000	337
Trujillo Arroyo	At Arrey		50	15000	300
Acoma Arroyo	Nr. Acoma		34	10000	294
Las Cruces Arroyo	Dona Ana County		14	4000	286
Dark Canon	At Mouth		442	100000	226
Arroyo Seco	Dona Ana County		18	4000	222
Dona Ana Arroyo	Dona Ana County		7.2	1500	210
Anthony Arroyo	Nr. Anthony		5.8	1000	173
Mora River	Nr. Mora		150	21000	140
Cameron Creek	Nr. Hurley		44	5940	135
Gallinas	Nr. Las Vegas		90	11610	129
Percha Creek	Nr. Hillsboro		122	15000	123

*Note: When the period of record is not shown maximum discharges are for the most part estimates and should be considered as such.

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Maximum Discharge C.F.S.	C.F.S. Sq.Mi.
Alameda Arroyo	Nr. Las Cruces		17	2000	115
Chico Rico Creek	Nr. Raton	15	64	6100	95
Mora River	Nr. Weber		294	27636	94
College Arroyo	Dona Ana County		23	2000	87
Penasco River	Nr. Hope		896	75000	84
Alamogordo Creek	Nr. Guadalupe		337	24800	74
Bermuda Creek	At Roswell		516	37700	73
Pena Blanca	Nr. Vado		28	2000	72
Santa Fe Creek	Nr. Santa Fe	13	11	655	60
Las Moras Creek	At Roswell		166	8860	53
Rio Felix	Nr. Hagerman		932	46840	50
Rio Tularosa	Nr. Tularosa		200	9640	48
Tierra Blanca	Nr. Derry		64	3000	47
Jaralsa Arroyo	Nr. Hatch		97	4300	44
Ponil Creek	Nr. Cimmaron	10	130	5800	45
Perico Creek	Nr. Clayton	5	114	5000	44
Rio Ruidoso	Nr. Hondo	12	307	12400	40
Pecos River	Nr. Anton Chico	12	1050	40300	38
Sapello	Nr. Los Alamos		221	8177	37
Rio Bonito	Nr. Hondo	12	306	11000	36
Delaware River	Nr. Red Bluff	7	967	34600	36
Rio Hondo	Nr. Diamond A Ranch	6	960	26500	28
Rio Hondo	At Riverside		896	24900	28
Santa Cruz	At Cundio	25	96	2610	27
Rio Medio	" "	14	38	995	26
Barrito	At Saragosa	25	612	15500	25
Rio Chama	Nr. Parkview	19	405	8530	21
Rio Felix	Nr. Hagerman	3	932	20000	21
Canadian	Nr. Taylor Springs	2	2740	37400	14
La Plata	N.M., Colo. Line	22	331	4750	14
Coyote Creek	Nr. Golondrinas	12	250	3020	12
Mimbres River	Nr. Mimbres	12	183	2060	11
Sapello River	At Sapello	14	70	769	11
Pecos River	Nr. Cowles	33	185	1800	10
Animas River	Nr. Farmington	38	1360	12800	9.4
Rio Colorado	Nr. Questa	26	112	886	7.9
Ojo Caliente	Nr. La Madera	10	445	2980	6.7
Rio Puerco	Nr. Rio Puerco	17	5160	28300	5.5
Rio Taos	Nr. Los Cordovas	31	359	1830	5.1
Embudo Creek	Nr. Dixon	12	305	1400	4.6
Rio Hondo	Nr. Valdez	12		541	
Arroyo Hondo	Nr. Hondo	32	614	2510	4.1
Rio Fernando de Taos	Nr. Taos	17	64	246	3.8
E. Fork Ocate	At Ocate	14	35	111	3.2

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Maximum Discharge C.F.S.	C.F.S. Sq. Mi.
		Utah			
China Wash	Nr. Hurricane		1.1	550	500
Farmington Canon	Nr. Farmington		7	2450	350
Wall Lake	Nr. Provo		2	700	350
Washington Lake	" "		3.4	1020	300
Coal Creek	Nr. Cedar City		92	2910	32
Little Cottonwood	Nr. Salt Lake City		28	692	25
Weber River	Nr. Oakley		163	4075	25
Whiterocks	Nr. Whiterocks	12	115	2750	24
Duchesne	Nr. Hannah	11	39	888	23
N. Fork Virgin	Nr. Springdale	16	336	7000	21
Ashley Creek	Nr. Vernal	31	101	2050	20
Price River	Nr. Helper	23	530	10000	19
Santa Clara Creek	Nr. Central	22	84	1450	17
Big Cottonwood	Nr. Salt Lake City	15	43	835	17
Assay Creek	Nr. Hatch		96	1632	17
Cottonwood Creek	Nr. Orangeville	26	200	2870	14
Virgin River	Nr. Virgin	23	934	13500	14
American Fork	Nr. American Fork		66	858	13
Huntington Creek	Nr. Huntington	27	188	2500	13
Henry's Fork	Nr. Lynnwood	14	531	6750	13
Beaver	Nr. Beaver	22	82	1080	13
S. Fork Ogden	Nr. Huntsville	21	148	1780	12
Lake Fork	Nr. Myton	27	468	5600	12
Logan	Nr. Logan		218	2398	11
Whiterocks	Nr. Whiterocks		110	1100	10
Uintah	" "		218	2180	10
Logan	Nr. Logan	23	218	2000	9
Ogden	Nr. Ogden		360	3240	9
Salt Creek	Nr. Nephi	11	94	800	8
City Creek	Nr. Salt Lake City	15	19	154	8
Hubble Creek	Nr. Springville		120	840	7
Black Fork	Nr. Hyrum		256	2002	7
Uintah River	Nr. Ft. Duchesne		672	4502	7
Duchesne	Nr. Tabiona	23	352	2500	7
Blacksmith Fork	Nr. Hyrum	22	260	1620	6
Provo	Nr. Provo		640	4100	6
Parley's Creek	Nr. Salt Lake		50	301	6
Emigration Creek	" " "	13	29	174	6
Mill Creek	" " "	15	21	128	6
Provo	Nr. Forks	24	600	3180	5
Diamond Fork	Nr. Thistle	10	137	735	5
S. Fork Provo	Nr. Vivian Park	30	30	123	4
Beaver	Nr. Adamsville	22	272	989	4
Spanish Fork	Nr. Thistle	18	490	1250	3
E. Canon Creek	Nr. Morgan	11	145	412	3
Beaver	Nr. Minersville	22	512	737	1

TABLE VII

AVERAGE ANNUAL RUNOFF
REGION 6

Watershed	Location	Period of Runoff	Watershed Area Sq. Mi.	Runoff Th. of Acre ft.	Acre ft. per Sq. Mi.
		Arizona			
Tabino Creek	Nr. Tucson	37	35	11	309
Bright Angel Creek	In Grand Canyon	19	100	30	298
Tonto Creek	At Roosevelt	55	813	102	125
San Carlos River	Nr. Peridot	13	1040	47	45
San Pedro River	Nr. Charleston	25	1250	51	41
Aravaipa Creek	Nr. Feldman	18	535	19	35
Santa Cruz River	At Nogales	29	522	18	34
Sonoita Creek	Nr. Patagonia	10	210	5.8	28
Rillito Creek	Nr. Tucson	33	903	18	20
Paria River	Nr. Lees Ferry	19	1570	26	17
Santa Cruz River	Nr. Tucson	36	2170	16	8
Whitewater Draw	Nr. Douglas	10	1023	7.0	7
Moencopi Wash	Nr. Tuba City	16	2490	17	7
San Simon Creek	Nr. San Simon	21	803	3.9	5
		Colorado			
Willow Creek	Nr. Ryans Ranch	12	5	7.8	1560
Uncompahgre River	Nr. Ouray	19	44	65	1479
Cascade Creek	Nr. Hesperus	24	27	38	1422
Elk River	Nr. Clark	29	206	268	1300
San Juan	At Pagosa Springs	9	298	356	1200
Navajo River	Nr. Edith	23	165	139	1187
Minas River	Nr. Tacoma	20	437	510	1169
Frazer River	Nr. West Portal	28	28	30	1079
Roaring Fork	Nr. Aspen	28	109	115	1053
La Plata River	Nr. Hesperus	21	37	36	968
Hanson Creek	Nr. Lake City	20	82	77	943
Colorado River	Nr. Grand Lake	34	101	93	919
Plateau Creek	At Collbran	18	88	76	863
Navajo River	Nr. Edith	26	165	138	840
Leroux Creek	Nr. Lazear	9	52	43	831
Soda Creek	Nr. Steamboat Springs	10	47	34	734
Blue River	Nr. Dillon	28	129	89	688
Eagle River	Nr. Red Cliff	15	74	49	665
Williams Fork River	Nr. Parshall	15	184	121	657
Pinos Creek	Nr. Del Norte	6	53	34	643
Yampa	Nr. Steamboat Springs	35	604	358	592
Snake River	Nr. Dillon	23	92	52	570

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Runoff Th. of Acre ft.	Acre ft. per Sq. Mi.
Kannah Creek	Nr. Whitewater	21	55	29	525
Surface Creek	Nr. Cedaredge	21	43	22	512
Trinchera Creek	Nr. Ft. Garland	13	45	17	377
Yerba Creek	Nr. Villa Grave	5	38	14	376
San Miguel River	Nr. Naturita	22	1080	286	266
Lightner Creek	Nr. Durango	15	66	17	264
Bear Creek	Nr. Morrison	12	170	40	234
Crooked Creek	At Mouth	4	79	11	144
Left Hand Creek	At Mouth	9	74	8.7	117
Timpas Creek	At Catlin Siphon	5	466	42	90
Wild Horse Creek	Nr. Holly	13	225	5.9	26
		New Mexico			
Rio Medio	Above Cundio	13	20	16	815
Rio Chama	Nr. Park View	25	405	287	708
Rio Frijoles	At Cundio	13	13	8.2	631
Red River	Above Questa	25	112	18	428
Pecos River	Nr. Pecos	11	189	80	425
S. Fork of Gallinas River	Nr. Porvenir	8	25	10	419
Santa Fe Creek	Above Santa Fe	13	22	8.6	391
Whitewater Creek	Nr. Mogollon	11	34	13	372
Sapello River	At Sapello	13	70	19	273
Six-Mile Creek	Nr. Eagle Nest	10	8.2	1.9	232
Embudo Creek	Nr. Dixon	18	305	66	216
Gallinas River	Nr. Montezuma	34	87	16	185
Rio Taos	Nr. Los Cordovas	30	359	44	124
Rio Fernando de Taos	Nr. Taos	16	64	2.0	109
Pecos	At Anton Chico	11	1050	14	108
Ponil Creek	Nr. Cimarron	13	130	10	79
Rio Ruidoso	At Hondo	11	307	18	59
Gila River	At Gila	14	1870	106	57
Mimbres River	At Mimbres	18	183	9.6	52
Vermijo River	At Dawson	31	250	13	51
Lamplight Draw	Nr. Santa Rita	10	37	1.3	35
San Francisco River	At Glenwood	13	1660	54	33
Ocate Creek	At Ocata		700	21	30
Rio Felix	Nr. Hagerman		1000	23	23
Black River	Nr. Malaga		350	4.4	12.6
Conchas River	At Variadero		1100	41	3.7
Pintada Creek	At Mouth		550	7.4	1.3

Watershed	Location	Period of Record	Watershed Area Sq. Mi.	Runoff th. of Acre ft.	Acre ft. per Sq. Mi.
	Utah				
Weber River	Nr. Oakley	16	163	194	1188
Uintah River	Nr. Whiterocks	9	165	176	1068
Duchesne River	Nr. Hannah	11	39	37	956
S. Fork Provo River	At Forks	8	30	24	812
Whiterocks River	Nr. Whiterocks	18	115	88	768
Mill Creek	Nr. Salt Lake City	14	21	13	614
City Creek	" " " "	11	19	12	604
Tabiona River	Nr. Duchesne	23	352	148	421
Ferron Creek	Nr. Ferron	13	140	59	420
Summit Creek	Nr. Santaquin	6	27	11	403
Cottonwood Creek	Nr. Orangeville	26	200	78	388
Huntington Creek	Nr. Huntington	27	188	72	384
Hobble Creek	Nr. Springville	10	120	45	371
Diamond Creek	Nr. Thistle	8	157	58	370
Blacksmith Fork	Nr. Hyrum	6	260	83	320
N. Fork Virgin River	Nr. Springdale	16	336	78	233
Price River	At Helper	21	530	116	220
Virgin River	At Virgin	23	934	162	174
Red Creek	Nr. Fruitland	5	89	13	151
Spanish Fork	At Thistle	9	490	72	148
Emigration Creek	Nr. Salt Lake City	5	29	2.4	81

PRINCIPAL SOURCES OF HYDROLOGIC AND CLIMATIC DATA IN REGION 6

The accompanying list of publications and reports has been compiled to acquaint the technician with available material concerning certain phases of the hydrology of Region 6. It is not offered as a complete hydrologic bibliography as no attempt has been made to include publications concerning such subjects as infiltration, sedimentation, etc., nor has consideration been given to papers or reports the purpose of which was to discuss individual phenomena or isolated occurrences. On the contrary, an effort has been made to confine the list to publications the sole purpose of which are to present useful information concerning climatology and stream flow with reference only to the Region as a whole, individual states, or certain watersheds.

The list has been separated into three parts: Climatology, Stream Flow, and Snow Surveys. In each case publications were listed in the order of the nature and extent of individual coverage rather than alphabetically. For example, the Weather Bureau publications contain the bulk of all meteorological data now available, while the other publications concerning precipitation, etc., contain for the most part summaries and conclusions drawn from this source.

With few exceptions, all of the material listed is available on loan in the Departmental Library at Albuquerque, New Mexico. If publications are needed and are not on hand in the Library, an attempt will be made to secure them.

Climatology

Climatological Data. U. S. Department of Commerce, Weather Bureau

Compiled at Phoenix, Arizona; Denver, Colorado; Albuquerque, New Mexico; and Salt Lake City, Utah. Published monthly. Contains daily precipitation, temperature, humidity, evaporation, and wind movement; statewide average of temperature and precipitation for the month and for same month during other years of record; also miscellaneous data such as comparisons of total precipitation and mean temperature with the normal, the number of days clear, cloudy, etc.

Climatological Data. U. S. Department of Commerce, Weather Bureau

Compiled at locations given above. Published annually. Data similar to that in monthly summary but no daily values included except in terms of annual means or totals. Contains date of first and last killing frost at selected stations.

Climatic Summary of the United States. U. S. Department of Commerce, Weather Bureau

States subdivided as follows: Northern and Southern Arizona; Western, Northeastern, and Southeastern Colorado; Northwestern, Northeastern, and Southern New Mexico; Eastern and Western Utah. Normally published

each decade. Last issue covers period of record through 1930 only, as national emergency stopped compilation of 1940 summary. Contains the following material: Description of general topographic features, precipitation, and temperature of each section; monthly maxima, minima, and mean temperatures, date of first and last killing frost from beginning of record where data are available; greatest precipitation recorded during 5, 10, 15 and 30 minutes and during 1, 2, and 24 hours, also periods of most excessive precipitation since beginning of record, where data are available; miscellaneous data such as average wind velocity, humidity, percentage of sunshine, number of days clear, cloudy, etc., where available.

<u>Hydrologic Bulletins</u>. U. S. Department of Commerce, Weather Bureau

Compiled by regions as follows: For Colorado, at Kansas City, Missouri; for New Mexico, at Fort Worth, Texas; for Arizona and Utah, at San Francisco, California. Bulletins set up on watershed basis. Published monthly. Contain daily and hourly precipitation from stations equipped with recording rain gages and only daily from others. Networks contain the majority of recording gages now in operation but record dates only from 1940.

<u>Climate and Man</u>. U. S. Department of Agriculture Yearbook. Government Printing Office, Washington, D. C., 1941.

Contains the following data from selected stations: Average monthly and annual precipitation, average date of first and last killing frost; January and July average temperatures; maximum and minimum temperatures recorded during period of record; and average length of growing season. Included also are descriptions of physiographic characteristics of each State and a discussion of average temperatures, humidity, etc.

<u>Climate and Accelerated Erosion in the Arid and Semi-arid Southwest, With Special Reference to the Polacca Wash Drainage Basin, Arizona.</u> C. W. Thornthwaite and others. U. S. Department of Agriculture, Technical Bulletin No. 808. 1942.

Data primarily concern the States of New Mexico and Arizona and include the following: A description of moist air mass sources and movements with respect to their influence on precipitation and temperatures characteristic of the Southwest; meteorological analyses of selected storms with a discussion as to the origin and movement of contributing air masses; variations in monthly and annual precipitation and frequencies of rainfall intensities at selected stations; and general climatic patterns typical of the two States. Considerable other miscellaneous data are also included.

<u>Rainfall Intensity-Frequency Data</u>. David L. Yarnell. U. S. Department of Agriculture, Miscellaneous Publication No. 204. 1935.

A scarcity of recording rain gage records in the Southwest and Rocky Mountain Region has made the determination of normal rainfall intensity-frequency very difficult. With the meager data available, however, Yarnell has prepared maps showing the depth of rainfall to be expected

in various localities during periods ranging from 5 minutes to 24 hours for frequencies of 2, 5, 10, 25, 50 and 100 years. In addition are tables containing the most intense rainstorms and maximum rates of precipitation recorded at each station together with other miscellaneous data.

Characteristics of Heavy Rainfall in New Mexico and Arizona. Luna B. Leopold. American Society of Civil Engineers, Vol. 69, No. 2, February, 1943.

A summary of 24-hour rainfall to be expected once in 10, 20, 50, and 100 years at a large number of stations in New Mexico and Arizona. Totals are separated into quantities during the summer months and all year. Actual records of many heavy rains have been plotted and a characteristic rainfall curve "laid in." The paper presents an excellent discussion of probable 24-hour catches in various zones within the two States and graphs showing the frequencies by months for each zone. Other subjects such as the aerial extent of heavy rainfall, air mass movement, etc., are also discussed.

Atlas of Climatic Types in the United States. C. W. Thornthwaite. U. S. Department of Agriculture, Miscellaneous Publication No. 421. 1941.

Contains a series of maps showing prevailing climatic conditions in the United States during each year for the period 1900-1939. Data are based on Thornthwaite's climatic classifications. In addition are maps of frequencies of certain climatic conditions as they can be expected to occur.

Maps of Seasonal Precipitation, Percentage of Normal by States. U. S. Department of Commerce, Weather Bureau Publication No. 1353, 1942.

Winter, spring, summer, and fall variations from normal are shown for each year of the period 1886-1938. Also included are tables showing the ten wettest and driest years on record.

The Climate of Arizona. H. V. Smith. University of Arizona Experiment Station, Tucson, Arizona. Bulletin No. 130. 1930.

A complete description of normal precipitation, temperatures, evaporation, etc., in the State.

The Climate of Colorado. Robert E. Trimble. Colorado Agriculture Experiment Station, Ft. Collins, Colorado. Bulletin No. 130, 1928.

Contains descriptive matter pertaining to the precipitation, temperature and other climatic characteristics of the State. Data concerning the climate at Ft. Collins are very complete, yet other specific information is limited to precipitation data at selected stations.

"Water Resources of Colorado," Appendix 1, Vol. 1, Climatological Data of Colorado. Colorado State Planning Board, Denver, Colorado, June 1939.

Contains records of annual precipitation from all Weather Bureau rain gages within the State since the date of their establishment. In addition, a wealth of other information is given, such as: maximum 24-hour rainfall during period of record; snow depths at various locations each year on March 1 and April 1; its water content and comparisons with the normal; complete evaporation data from Colorado stations and those in surrounding States; maximum discharges during period of record for certain streams in Colorado and New Mexico; and maps and graphs showing the quantity and distribution of precipitation, the topography of Colorado, etc.

Precipitation and Evaporation in New Mexico. Erle L. Hardy and others. New Mexico College of Agriculture & Mechanic Arts, Experiment Station, State College, New Mexico. Bulletin No. 269, 1931.

Contains average monthly, seasonal, and annual precipitation of all Weather Bureau stations in New Mexico and graphs of precipitation showing totals by years for selected stations. Complete data from all evaporation stations are also included. Periods covered by the records are, however, for the most part rather short.

The Climate of Utah. Frank L. West and N. E. Edlefsen. Utah Agricultural College Experiment Station, Logan, Utah. Bulletin No. 166, March, 1919.

A summary of characteristic precipitation, temperatures and frost data for all stations then existing at that time in Utah. Also additional information such as monthly precipitation, incidence of summer rains, etc., for one selected station in each county, usually the county seat.

Stream Flow Data

Water Supply Papers. U. S. Department of Interior, Geological Survey. Published annually.

Compilation of records taken from gaging stations located on major and minor streams throughout the United States. Data include total daily discharges, monthly maximum, minimum, and mean discharge in second-feet and total annual runoff in acre-feet. In addition, the maximum and minimum instantaneous rates of runoff during the period of record are given. Papers concerning runoff are entitled "Surface Water Supply of the United States" and are compiled annually by basins or portions of basins. Virtually all of Region 6 is included in five papers, the titles and pertinent streams of which are as follows:

- Western Gulf: Rio Grande, Pecos Rivers and tributaries.
- Colorado River: Colorado, Green, Salt, Gila Rivers and tributaries
- Great Basin: Weber, Jordan, Bear Rivers and tributaries.
- Lower Mississippi River: Arkansas, Canadian, Cimmaron Rivers and tributaries.
- Missouri River: South Platte River and tributaries.

Publications of the Geological Survey. U. S. Department of Interior, Geological Survey. July, 1942.

An index of many Water Supply Papers covering special investigation of particular basins, such as those of the Green and Colorado Rivers.

Arizona Stream Flow Summary. Colorado River Commission of Arizona. Phoenix, Arizona, 1940.

Although the report was not prepared primarily as an outline of discharge records, the data contained therein may be found very useful if summarized stream flow records are desired. Total runoff in terms of acre-feet per square mile from various watersheds is given, and probable water losses are discussed.

"Water Resources of Colorado," Appendix No. 3, Vols. I and II, Stream Flow Data of Colorado, Colorado State Planning Board, Denver, Colorado. June, 1939.

Volume I contains records from the North Platte, South Platte, Republican, Arkansas, and Rio Grande River Basins and their tributaries in Colorado.

Volume II contains records from the San Juan, Colorado, and Green River Basins and their tributaries in Colorado.

These data are undoubtedly the most extensive yet compiled. Records taken by the Geological Survey and the Colorado State Engineer have been combined and their differences reconciled. Estimates were made in lieu of actual records when such was considered justifiable.

The publications contain tables of monthly and total annual runoff at each gaging station from the beginning of record through 1938. In addition, monthly and annual quantities are compared with the mean. Watershed areas and the elevations of gaging stations are also included.

"Water Resources of Colorado," Appendix No. 2, Vol. I, Data on Stream Gaging Stations of Colorado. Colorado State Planning Board, Denver, Colorado. May 1939.

Contains excellent tabulations of runoff from gaging stations in the State. Data included are: average maximum and minimum 24-hour discharge, mean discharge, annual maximum, minimum, and mean discharge and average runoff equivalent in inches over the watershed. Other tables contain the locations of gaging stations by description and Section, Township, and Range; elevations of stations; watershed area above each; lengths of records and periods covered.

Progress Report of the Navajo Soil and Water Conservation Experiment Station, Mexican Springs, New Mexico. Soil Conservation Service. 1934-1939.

Contains records of total rainfall and runoff and maximum rates of rainfall and runoff recorded at six watersheds ranging in size from

187 to 46,080 acres. Records cover the period 1937-1939. Complete descriptions of each watershed are included in tabular form. Also contained in the report are rainfall-runoff relationship graphs from selected storms and very complete records of climatic data such as temperatures, evaporation, humidity, wind movement, etc., during the period 1934-1939.

Davis County, Jordan River Drainage Systems in Utah: Great Basin, Bear River Drainage System; The Weber River Drainage System in Utah; Utah Lake Drainage System. Utah State Planning Board, Salt Lake City, Utah, 1937.

Summaries of mean annual and monthly runoff (total) from various watersheds. Primarily condensed U. S. Geological Survey data. Each watershed is separated into proportion of area by elevation. Certain temperature and precipitation data are also given.

Biennial Reports of the State Engineers; Colorado and New Mexico

Colorado: contains daily discharge measurements for the preceding two (water) years and total monthly and annual maximum, minimum, and mean runoff. Also included are descriptions of each gaging station and the maximum and minimum instantaneous discharges recorded since establishment of the station.

New Mexico: contains detailed reports on hydrographic surveys that have been carried on during the two-year period. These include average precipitation, temperatures, runoff, and other pertinent data concerning the particular watersheds.

Water Facilities Area Plans. Bureau of Agricultural Economics, Washington, D. C.

Some 25 plans covering watersheds within the States of Arizona, Colorado, Utah, and New Mexico have been developed. Each contains descriptions of the physiographic characteristics and data concerning precipitation, temperatures, runoff, etc., peculiar to a given area. Watersheds or portions of watersheds covered are as follows:

Arizona: Kirkland Creek; Northern Sulphur Springs Valley; Upper San Pedro Watershed; Upper Virgin River (partially in Utah); Verde River; Vernon Area, Mineral Creek; Whitewater Draw.

Colorado: Gypsum Creek; Little Dolores River (partially in Utah); North Fork of Cimmaron River (partially in Kansas); North Fork of Gunnison River; Republican River (partially in Kansas and Nebraska); Upper Yampa.

New Mexico: Alamosa River, Rio Cuchillo Negro, et al; Mora River; Ocate Creek; Quay Curry Area; Rio Moquino; Rio Santa Cruz; Rita Blanca (partially in Texas); Upper Rio Puerco Watershed.

Utah: Sanpete Area; Nebo Area.

Flood Control Surveys. U. S. Department of Agriculture, Soil Conservation Service, Albuquerque, New Mexico.

A considerable number of preliminary reports covering various watersheds within Region 6 were completed during the latter part of the "Thirties."

Hydrologically, the average survey is complete insofar as data are available and offers an excellent summation of normal temperatures, precipitation, runoff, etc. Descriptions of watershed characteristics are also included.

All or portions of the following basins are covered:

Arizona: Queen Creek; Little Colorado River (partially in New Mexico); Gila River (partially in New Mexico); Bill Williams River; Lower Gila River; Virgin River (partially in Utah).
Colorado: Apishapa Watershed; South Republican River, San Luis Valley of Rio Grande; Cherry Creek; Fountain River; Huerfano and Cucharas Rivers; Purgatoire River; Smoky Hill River (partially in Kansas); South Platte River (partially in Wyoming and Nebraska).
New Mexico: Canadian River above Conchas Dam; Pecos River; Cimmaron River; Rio Grande Watershed above El Paso, Texas; Rio Puerco Watershed; Trujillo Arroyo Watershed; Santa Cruz Watershed.
Utah: The Great Salt Lake Watershed.

National Resources Planning Board. Washington, D. C.

The most comprehensive hydrologic surveys to date have been compiled by the Board on the Upper Gila River of Arizona and Upper Rio Grande and Pecos Rivers of New Mexico and Colorado.

Forest and Stream Flow Experiment at Wagon Wheel Gap, Colorado. C. G. Bates and A. J. Henry. Monthly Weather Review No. 946, 1928.

Contains 17-years record of temperature, precipitation, stream flow, evaporation, snowfall, etc. Data are from two adjacent watersheds having areas of 200 and 225 acres. Elevations of the areas range from 9,245 to 11,355 feet.

Snow Surveys

Snow Surveys and Irrigation Water Forecasts. U. S. Department of Agriculture, Soil Conservation Service, Division of Irrigation and others, Fort Collins, Colorado.

Four bulletins issued monthly from February to May, inclusive. Basins covered are of the Arkansas, Colorado, Missouri, and Rio Grande Rivers and their tributaries.

Data include: average total precipitation over basin from October of preceding year to date of survey; precipitation during preceding month; departures from the average; average snow depth and water content on first of month and comparisons with the preceding year and the normal. In addition, each publication contains a summary of snow storage conditions and forecasts of probable water supply during the irrigation season.

Utah Cooperative Snow Surveys and Water Supply Forecasts. George D. Clyde, Utah Agricultural Experiment Station and others, Logan, Utah.

Issued each year on March 1 and April 1. Bulletins contain: forecasts of April-September and July-September runoff from watersheds covered by snow courses; comparisons of conditions during a particular year with those of the preceding year and the average; and reservoir storage as of the date of issuance. Also included are recommendations as to the usage of water during the forthcoming irrigation season and a forecast of the maximum discharges to be expected.

Monthly Snowfall and Temperature Bulletin. U. S. Weather Bureau.

Issued monthly from December 1 to April 1 at Denver, Grand Junction, and Pueblo, Colorado; Phoenix, Arizona, and Albuquerque, New Mexico. Basins covered by the reports are of the following rivers: Upper North Platte, South Platte, Upper Colorado, Upper Arkansas, Purgatoire, Lower Colorado, Salt, Gila, Upper Rio Grande, San Juan, Pecos, and Upper Canadian.

Data are based on reports from Weather Bureau Stations and include the following: snowfall during preceding month and water equivalent; cumulative snowfall since November 1 and depth of snow on ground at end of preceding month. These are in terms of individual stations. Also included are reservoir storages at end of period and summaries of average snow depth over each watershed as compared with the normal.

OTHER BIBLIOGRAPHIES

If more extensive and complete lists of sources of the broad field of hydrologic data are desired, they can be found in the following publications:

Principal Sources of Hydrologic Data. National Resources Planning Board, Washington, D. C., Technical Paper No. 10. May, 1943.

Publications on Water Resources: Their Use and Development in the Western States. Soil Conservation Service, Division of Information. May, 1941.

Bibliography of Hydrology, United States. American Geophysical Union. Published annually.

Several other excellent bibliographies of various phases of hydrology are also available and are listed in the first named publication above.